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AUTHOR Blackburn, Mary; And Others
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ABSTRACT

Print masters for 87 exercises in diagnostic and formative testing of science comprehension skills are provided for reproduction and test construction. Passages from science periodicals and general science texts are presented with questions testing vocabulary, conceptual, and content comprehension. Research questions are included in the program for use in grades 7 through 10. TM 820 314 provides the teachers' manual accompanying the exercises. (CM)

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SCIENCE

LIBRARY OF TEST ITEMS

Comprehension Testing Program - 2

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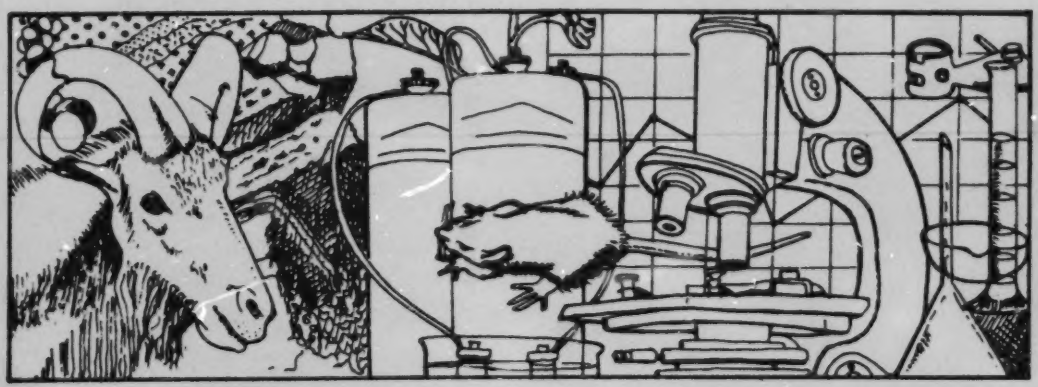
PART 4 : PRINT MASTERS FOR REPRODUCTION
(EXERCISES 64 - 150)



TM 820 3/5

VOLUME FIFTEEN OF THE SCIENCE LIBRARY OF TEST ITEMS

The content of the Science Library of Test Items project, of which this is Volume Fifteen, is as follows:

Volume One:	A collection of multiple choice items
Volume Two:	A second collection of multiple choice items
Volume Three:	Introduction and Manual to Mastery Testing
Volume Four:	The Practical Testing Guide
Volume Five:	Readability and Science Testing
Volume Six:	Comprehension Testing Manual
Volume Seven:	Print Masters for Comprehension
Volume Eight:	Series 3 & 4 Supplement to Mastery Testing
Volume Nine:	Mastery Tests Series 1 (M1 - M13)
Volume Ten:	Mastery Tests Series 2 (M14 - M26)
Volume Eleven:	Mastery Tests Series 3 (M27 - M38)
Volume Twelve:	Mastery Tests Series 4 (M39 - M50)
Volume Thirteen:	Mastery Tests Series 5 (M51 - M65)
Volume Fourteen:	Comprehension Testing Manual - 2
Volume Fifteen:	Print Masters for Comprehension - 2

The following volumes are in various stages of production and should be finalised by the end of 1981:

Volume Sixteen:	Mastery Tests Series 6 (M66 - M80)
Volume Seventeen:	Biology Test Items
Volume Eighteen:	Physics Test Items
Volume Nineteen:	Chemistry Test Items
Volume Twenty:	Geology Test Items
Volume Twentyone:	Processes in Science Test Items
Volume Twentytwo:	Mastery Tests Series 7 (M81 - M95)
Volume Twentythree:	Mastery Tests Series 8 (M96 - M110)

All material in the project is made available in the hope that teachers will select those parts which are of use to them in developing their own testing programmes.

ISBN-0-7240-5873-7

Comprehension Testing Program 2

PART 4 : PRINT MASTERS FOR REPRODUCTION (EXERCISES 64-150)

PRODUCED BY SCHOOL CERTIFICATE DEVELOPMENT UNIT, DIRECTORATE OF STUDIES

1981

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SOURCE: Life Science Library - "Energy" ★★

EXPANSION 64

Expanding hot gases drive the pistons in an engine and move a car. Solids and liquids also expand when heated. The amount of expansion for each degree of temperature increase depends upon the substance. For example, because the thermal expansion of metal or plastic is different from that of glass, housewives often run hot water over metal covers of food packed in jars, or on the plastic tops of nail polish bottles. This act of heating the lids causes the metal or plastic to expand, loosening the grip on the container. By the same token, heat tends to make metal pendulums of clocks longer. Therefore, grandfather clocks, unless corrected, run slower in summer than in winter.

Expansion is of great technological importance because it frequently causes engineers to provide necessary allowances for many structural materials. A kilometre of railway track, for instance, expands as much as 60 cm in summer heat. So too, a 300 metre metal bridge may change its length by 20 centimetres. At the same time as the road bed is expanding, supporting uprights lengthen. Unless allowances can be made for this, a bridge road would buckle considerably.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? thermal (line 4), pendulum (line 9), technological (line 11), structural (line 12).

2. Why can lids be more easily removed from jars by running hot water over them?

3. What could cause bridges to buckle in summer?

4. (a) What is thermal expansion (line 4)?

   (b) Place these substances in order of decreasing thermal expansion.
   (i) glass (ii) metal (iii) plastic

5. Grandfather Shadwick shifted from Darwin to Melbourne, taking his grandfather clock with him. Would his clock run faster, slower, or keep correct time? Support your answer using evidence from the passage.

6. What does by the same token (line 8) mean?

RESEARCH QUESTIONS

7. The average length of a section of railway track is about 20 metres.

   (a) How many lengths are there in one kilometre of track?

   (b) What gap must be left between each section to make allowance for the expansion mentioned in the passage?

8. (a) What allowances are usually made for expansion on large metal bridges? (e.g. Sydney Harbour Bridge).

   (b) Draw a diagram to show what this looks like.

9. Describe 3 other situations where an allowance must be made for thermal expansion. Give 1 example each for a solid, a liquid and a gas.

10. Thermal expansion can also be used to man's advantage. Describe, using diagrams where necessary 3 uses man makes of (differing) thermal expansion (one each for gases, liquids and solids).

★★

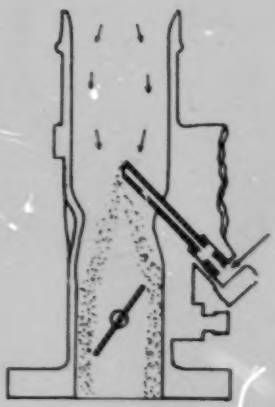
SOURCE: Adapted from C.M. Tempest "Automative Service Technology" Book 1, Sydney, Angus and Robertson, 1966 pp.60-61.

THE CARBURETTOR

65a

The carburettor, such as that used in a car, is a measuring instrument which provides properly proportional combustible mixtures of atomized fuel and air to suit engine requirements over a wide range of speeds and loads.

A simple carburettor consists of a short length of tube with a restricted section, a fuel nozzle, and a disc-or butterfly-type throttle valve. The main tube is called the *air horn*, the restricted section is the *venturi*, and the valve is known as the *throttle valve*. The venturi causes an increase in air speed at the small diameter, and due to its special shape as it opens out again a partial vacuum is produced in the venturi.



The greater the air speed, the greater the flow of fuel from the *fuel nozzle*. The opening and closing of the throttle valve increases or decreases the flow of fuel mixture to the engine and thus controls its speed. When the valve is open the flow is maximum and when closed the flow of fuel mixture is minimum.

Do not write any answers on this sheet. All answers are to be written on your own paper or in your book.

1. What do these words mean, as they are used in the article? proportional (line 2), combustible (line 2), atomized (line 2), partial (line 17).

2. Copy this diagram of a carburettor into your books and on it label the arrows using the words:
venturi, *air horn*,
throttle valve,
fuel nozzle.

3. The carburettor that you have just drawn shows the throttle valve in a certain position. In this position a car would most likely be travelling at about

A. 0 kilometres per hour. C. 30 kilometres per hour.
B. 15 kilometres per hour. D. 45 kilometres per hour.

4. Below are 3 diagrams of the main component of a carburettor. On the diagrams draw the position of the throttle valve of a car moving at 40 kph, 80 kph and 120 kph respectively.

5. What instrument, operated by the driver of the car, would control the throttle valve?

6. What causes the fuel to be drawn up the fuel nozzle?

7. (a) What is the relationship between the speed at which the air moves through the venturi and the rate at which fuel flows out of the fuel nozzle?
(b) What does this indicate about the air *pressure* in the vicinity of the venturi as the air *speed* increases?

RESEARCH QUESTIONS

8. The effect which makes the carburettor of a car work was first expressed in mathematical form by Daniel Bernoulli in 1738 and is called *Bernoulli's principle* or the *Bernoulli effect*. What, in simple terms, is the Bernoulli principle?

9. In about a page of writing find out about the life and work of Daniel Bernoulli. What were his major contributions to science?

10. An atomizer and the lift on an aeroplane wing also use Bernoulli's principle. Find out how these work. Use diagrams, appropriately labelled, to illustrate your answer.

11. Find out some other cases where the Bernoulli principle is used.

SOURCE: Life Science Library - Energy. ★★

CHANGING STATE

66a

In his pioneering research on heat, Joseph Black used the thermometer to study many things which had previously defied understanding. To his predecessors, it had seemed logical that a kettle of water kept on a stove would get hotter and hotter. In boiling it should continue to increase in temperature until all the water boiled away.

Black established that water ceases to get hotter after it has reached 100°C but it still boils away. Black also established that a mixture of ice and water remains at the same temperature, though heat may be added or lost, until it changes entirely to ice or water.

In observing ice melting into water and water vaporizing into steam, Black recognized that heat was necessary for these changes. His conclusion was that water in the form of ice stays solid at 0°C because it lacks a sufficient amount of heat to change itself into a liquid. He further concluded that water never becomes hotter than 100°C because at that temperature it completely takes in all the heat that is available in the process of changing itself from a liquid into a gas. In the reverse process when water changes from a liquid to a solid or a gas into a liquid, Black hypothesized the presence of what he called "latent heat". In order for water to freeze, he reasoned the latent heat was to be taken out.

"My conjecture, when put into form, was to this purpose," Black wrote, "I imagined that, during boiling, heat is absorbed by the water, and enters into the composition of the vapour produced from it. In the same manner heat is absorbed by ice in melting, and enters into the composition of the produced water."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? pioneering (line 1), predecessors (line 3), vaporizing (line 10), sufficient (line 13), hypothesized (line 18), conjecture (line 21), absorbed (line 22).

2. What observations led Black to hypothesize that substances contain *latent heat*?

3. Using your dictionary, find the meaning of the word 'latent'? What does latent heat mean (line 19)? Why is the word latent an appropriate word to use in this context?

4. What is the difference between temperature and heat?

5. Indicate whether latent heat is absorbed or lost in the following changes of state:
   (a) ice melting
   (b) water freezing
   (c) butter melting in a frypan
   (d) water changing into steam
   (e) gas condensing to a liquid.

6. We make use of <u>latent heat</u> in several appliances. Name two appliances which rely on <u>latent heat</u> for their operation and describe how they work.

7. Explain the following observations in terms of the idea of latent heat:
   (a) perspiration cools you down.
   (b) wet newspapers, wrapped around cans of drink, keep the cans cool on a picnic.
   (c) a cold day becomes warmer if it starts to snow.

SOURCE: Understanding Science ★★★

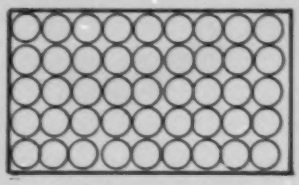
STATES OF MATTER 67a

The three states of matter are solids, liquids and gases. We are used to thinking of some things as solids, and of others as liquids, even of a few as gases. We *know* which are which.

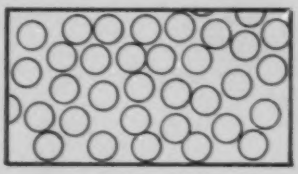
But we are only right within the temperature range in which we live. Lower or higher temperatures cause matter of every sort to change its state.

Copper, which we think of as a solid, can be changed into a liquid or a gas. Hydrogen, which we think of as a gas can be changed into a liquid and even a solid. Of course, we are unlikely to see these changes as the temperatures needed are very extreme. However, the changes can occur.

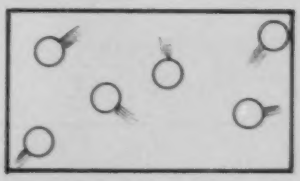
The smallest possible piece of any material is an atom. The difference between solid, liquid or gaseous states is the amount of movement the atoms and the molecules (groups of atoms) make.



In the solid state, the atoms or molecules are packed closely together. They do not move about. They just vibrate back and forth while staying in fixed positions. This makes it difficult to press solids into new shapes.



In the liquid state the molecules are just as close together, but they can roll past one another. The hotter the liquid is, the faster the molecules move. Because the molecules can move like this so easily a liquid has no fixed shape, in fact it always fits the bottom of whatever contains it.



It is difficult to believe that a solid metal can actually turn into a gas. However, at very high temperatures the atoms of the metal move so fast that they break away from each other and form into the gaseous state. They then move freely and take up a great deal more room than as a solid or a liquid. There is a lot of space between each atom. It is therefore easy to compress a gas. It is just a matter of reducing the space between the atoms. Like a liquid, a gas has no shape, but unlike a liquid it will spread out to fill its container completely.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   temperature (line 4), range (line 4), material (line 12), vibrate (line 17), compress (line 35).

2. What makes solids, liquids and gases different from each other?

3. What words are used in the passage to describe the way the atoms or molecules in (a) solids, (b) liquids and (c) gases move?

4. Why is it that gases can be compressed, while liquids and solids can not be compressed?

5. In paragraph 3, changes in copper and hydrogen are mentioned. State, for each of the changes mentioned whether the temperature has to rise or fall for the changes to occur.

6. The last paragraph mentions that a gas will "spread out to fill its container completely". What one word in science describes this process?

7. Explain the following things about solids, liquids and gases in terms of the way their atoms or molecules are arranged and can move.
   (i) gases can be compressed.
   (ii) solids have a fixed shape.
   (iii) gases occupy all their container.
   (iv) liquids can be poured.
   (v) solids do not diffuse.

RESEARCH QUESTIONS

8. What one word name is used to describe the following changes?
   (i) solid → liquid.
   (ii) liquid → gas.
   (iii) solid → gas.
   (iv) gas → liquid.
   (v) liquid → solid.
   (vi) gas → solid.

9. (a) What is the difference between an atom and a molecule? Use diagrams to help your answers.

   (b) What is an element?
   What is a compound?

   (c) What is the difference between the molecule of an element and the molecule of a compound? Use diagrams if you wish.

10. (a) What is the temperature range for
   (i) Sydney.
   (ii) The Snowy Mountains.
   (iii) The Nullarbor Plain.
   (iv) Darwin?

   (b) In which of these places would you be most likely to find water as (i) a solid.
   (ii) a liquid.
   (iii) a gas.

SOURCE: Life Science Library - "Energy" ★★★★

BOILING

68a

The surface of a liquid such as water, acts as a sort of barrier to the outer world. For instance, a molecule below the surface, travelling upwards at a high velocity, may pass out of the liquid into the atmosphere. To do this the molecule must do work against the surface as well as against air pressure. Only when the temperature is high enough does the average energy of the liquid allow an appreciable escape of molecules into the atmosphere.

The fastest molecules escape as heat is added. They break through and away from the surface. They transfer some of their energy to the atmosphere. As the heat applied to the liquid continues, more and more molecules attain speeds which enable them to escape through the surface. When enough of the molecules reach this point, the surface of the liquid becomes quite violently agitated. The liquid boils.

At the boiling point each addition of heat energy is divided among the molecules left behind in the liquid. Eventually, their speed rises until they, too, can escape. In other words, a steadily heated liquid rises in temperature to a certain point at which the temperature becomes constant while the liquid boils away.

Kinetic theory explains this process as a matter of increasing the velocity of each molecule to the point at which its kinetic energy is sufficient to break free from the attractive forces of each neighbouring molecule.

At this point, a change of state occurs. The liquid becomes a gas. The energy used up in the process of changing state is called latent heat.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? molecule (line 2), agitated (line 13), process (line 15), latent (line 24).

2. What do the following terms mean as they are used in the article?
average energy (lines 5 and 6), boiling point (line 14), kinetic theory (line 19), kinetic energy (line 20), attractive forces (line 21), change of state (23).

3. (a) The terms velocity (line 3) and speed (line 11) are commonly used to mean the same thing. However in science they have distinct and different definitions. Define each as it is used in science.

   (b) In this article, are the two words used in their common or scientific senses?

4. What has to happen before a molecule of a liquid can escape from the liquid?

5. What happens to the additional energy added to a liquid after it starts boiling?

6. (a) What is the difference between a molecule and an atom?

   (b) Why does the writer of the passage refer to molecules and not to atoms?

7. What process is being referred to in line 24)?

8. Rewrite the second last paragraph which starts "Kinetic theory explains .... " in your own words.

9. The article refers to attractive forces (line 21). These differ in type, or in strength from molecule to molecule. Write notes to explain how these forces affect the boiling point of a liquid.

10. (a) List these substances in order of decreasing attractive forces between their molecules.
water, alcohol, mercury, ether, iodine, carbon dioxide, oxygen and sugar.

(b) How did you decide on this particular order?

★★★

ENERGY CHANGES

69a

The interchangeability among its various forms is one of the most important properties of energy. Physicists can imagine *no* exception to the statement that any form of energy can be converted into any other. Sometimes the conversions seem a little awkward and roundabout. For example, we do not ordinarily try to change mechanical into heat energy directly. Yet it can be done - easily. Rubbing two sticks together generates enough heat to start a fire. Similarly, it is almost impossible to convert heat directly into electrical energy. Instead, man uses heat to run a turbine and the mechanical energy of the turbine will spin a generator to "create" electricity.

Because the intervening mechanical step is expensive and inefficient engineers are seeking breakthroughs in technology which will convert heat *directly* into electricity. Devices to do this already exist but only on a laboratory scale. Light offers another thorny problem in conversion.

Although a limitless amount of radiant energy falls on the earth every day and is "wasted", man has no truly efficient way to capture this energy for work. Only the green plants of the earth are able to do it on any large scale, although promising man-made devices are coming into use.

Perhaps the most difficult of all the transformations is that from any other form of energy to nuclear energy. It does occur, but the atomic physicist is the only one to witness the transformations. For example, in one very delicate laboratory experiment, light has been observed turning back into the substance of the atom. However, even that one transformation is enough to satisfy a physicist. All other forms of energy can be turned into light and all of them conceivably could be put into a nuclear form.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   interchangeability (line 1), properties (line 2), converted (line 3), generates (line 7), turbine (line 9), generator (line 10), intervening (line 11), efficient (line 16), transformations (line 21).

2. Several energy changes are listed in the passage as being fairly difficult to accomplish. List them.

3. Briefly describe how man produces electrical energy.

4. (a) Explain why the word "wasted" (line 16) has been placed in inverted commas.
   (b) Is "create" (line 10) the correct word to use in this context? Explain. Write down one other word which describes what is meant by "create".

5. What scientific law does this article describe? Write this law out in full.

6. What is meant by the sentence However, even that one transformation is enough to satisfy a physicist?

7. This article mentions physicists, technologists and engineers. What does each of these people do? Compare and contrast their roles.

8. The passage uses 6 different terms all saying that one form of energy can be changed into another. Find them.

9. Why do scientists consider the Law of Conservation of Energy an important principle in Science?

10. Man is starting to harness solar energy - not economically yet, but it is a start. Explain, using diagrams where necessary, how either a solar cell, or a solar hot water system works.

11. Some recent solar energy devices include a solar barbecue. Find out how and why this works, and see if you can build a simple solar barbecue using an old tin can.

★★

ULTRA VIOLET

70

In 1801, the German scientist Johann Ritter found that at the violet end of the spectrum were invisible rays which were especially effective in promoting chemical reactions. Ritter's discovery came to be called the chemical spectrum. The exact nature of this spectrum did not become known through scientific investigation. Rather, it was examined as a result of a highly commercial invention - photography. In 1839, the Frenchman Louis Daguerre popularized a process for taking pictures on metal plates coated with silver salts.

Science soon capitalised on Daguerre's process to make spectral photographs. Beyond the violet band, a whole new section was recorded on the silver plates. It was invisible to the eye, and named "ultra-violet" (UV).

The human skin also reacts to UV radiation. UV is the part of sunlight which causes sun-tan. Biologists have established that uncontrolled UV rays kill the cells of pure white skin. The white man's slowly acquired sun-tan and the permanent pigmentation of the dark-skinned races serve as effective UV filters. These protect the body cells from damage by the rays which are present in sunlight.

The effects of UV, however, are not all bad. It helps the body make vitamin D. It is used as the so-called "black light" that causes special luminous signs to glow in the dark. Discos use UV lights for special effects - it makes white clothing, in particular, glow superbly.

Home sun-tan lamps use special quartz glass and contain a little mercury. When the electric current vaporises the mercury, the resulting glow contains UV. Quartz glass must be used as ordinary window glass is opaque to UV. This is familiar to anyone who has tried to get a sun-tan through a closed window.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?

   spectral (line 9), band (line 10), established (line 13), pigmentation (line 15), luminous (line 20).

2. Why was Ritter's discovery called the chemical spectrum (line 4)?

3. Give 3 properties of UV radiation as mentioned in the passage.

4. If UV was discovered in 1801, why wasn't it analysed until after 1840?

5. What are spectral photographs (lines 9 and 10)?

RESEARCH QUESTIONS

6. There are two types of spectral photographs used by scientists today: emission spectra, and absorption spectra. Briefly describe each and their differences.

7. What have "blue beads of bleach" found in some washing powders to do with "black lights" used in discos?

8. How does pigmentation (line 15) protect skin from UV radiation?

9. What is vitamin D (line 19)? How is it made and what purpose does it serve in our bodies?

SOURCE: Life Science Library - "Energy". ★★★

71

INFRA-RED

Soft as the touch of visible light usually is, it is one of the two forms of radiant energy that human senses can detect directly. The other form is infra-red heat energy.

The fact that infra-red energy is a form of invisible light was discovered by Sir William Herschel at the turn of the nineteenth century. Herschel, a pioneer of stellar astronomy, began examining light from sunspots through differently coloured filters. In 1800, he discovered that some produced the effect of heat, others did not. He sought the cause of this difference.

Using a prism he spread a beam of sunlight into the continuous band of colour known as the spectrum. He observed that yellow was the brightest light and that red gave off the greatest heat. To his surprise, however, the highest temperature of all occurred in invisible radiation just below the visible red light. This infra-red light is a prominent part of the radiation which we now recognise as being thrown off by any hot object.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in this passage?
   radiant (line 2), stellar (line 6), prism (line 10), spread (line 10).

2. What direct observation caused the discovery of infra-red radiation?

3. What was Herschel trying to do when he found infra-red radiation?

4. Draw a diagram which shows how a prism would spread a beam of sunlight. What is this spreading (line 10) called in physics?

RESEARCH QUESTIONS

5. What is the literal meaning of infra-red?
   What are some of the uses of infra-red radiation?
   Is it dangerous?

6. Heat energy can be transferred in several ways. Thrown-off (line 15) roughly describes one of these. Describe each way in which heat can be transferred.

7. Herschel was a stellar astronomer (line 6).
   What does a stellar astronomer do?

8. How many Herschels were involved in astronomy?
   Who were they, and what did they discover?

★★★

SOURCE: Progress Column in the Sun-Herald, April 22, 1979, p.162.

ELECTRICITY FROM THE SUN

72a

The recent announcement of a grant to researchers at the University of N.S.W. for the development of a new type of solar cell is noteworthy. The solar cell will undoubtedly play an important part in the future energy situation. It is already playing a vital role in space technology. If solar cells or batteries are already employed for space technology it might be wondered why intensive research is still necessary. It is because of the cost of production and the efficiency of operation. The principle of how the solar cell works is not new. As far back as 1839, Becquerel discovered that the electromotive force of certain type of voltaic cell changed if one electrode was strongly illuminated.

FROM RADIOS TO BUSES

The solar cell is a unit to convert radiant energy directly into electricity. That is why it is so suitable as a power supply for space craft as the cells can be continually activated by interrupted exposure to sunlight, but such cells can be used to power anything from satellites to transistor radios and even road vehicles.

It should be remembered that the activating factor is light, not heat - although heat can also be utilised if required by means of a thermo-couple which works on the principle that when two different metals in contact are heated, an electric current flows through them.

A typical modern solar cell consists of a wafer-thin piece of silicon, smaller than a razor blade. There are actually two layers of silicon each with a different electrical property so that when sunlight strikes the cell, electrons move from the first or positive layer to the second or negative layer thus producing a flow of current.

RESEARCH

One of the main technological objectives of the late '70s has been efficient direct conversion of solar energy to electricity. Crystalline silicon solar cells can perform the task with an efficiency of 22% but they are too expensive for large scale production. Experimenters at the University of Dundee, Scotland, prepared special thin films of amorphous silicon, the electrical conductivity of which could be varied by a factor of 600 to 1000 by the addition of small amounts of phosphorus and boron.

Australian research is directed at eliminating the need to introduce impurities. This is achieved by means of a very thin insulating layer which is "grown" on top of the silicon.

The overall result is a considerably increased energy conversion efficiency. But, the method also seems to hold the possibility of using low grade silicon - thereby putting large scale commercial production within practical reach.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words as they are used in the passage?

   vital (line 4), intensive (line 6), efficiency (line 7), electrode (line 9), illuminated (line 10), activated (line 14), amorphous (line 31).

2. The following phrases are used in the article. What do they mean?

   space technology (line 4), electromotive force (line 9) radiant energy (line 12), solar energy (line 28) electrical conductivity (line 32)

3. (a) What is a thermo-couple (line 18)?
   (b) How does it work?
   (c) How could you make a simple thermo-couple?

4. What energy conversion is taking place in a solar cell?

5. What advantage is there in having solar cells operating in space rather than in the earth's atmosphere?

6. What is meant by the statement that crystalline silicon solar cells have "an efficiency of 22%" (line 29)?

7. What are the experiments at the University of Dundee aiming to do?

8. What are Australian researchers doing in this field? What have they found out so far?

RESEARCH QUESTIONS

9. What sort of substances are silicon, phosphorus and boron?

10. To what use could solar cells be put to on earth? Are they used very much at present?

11. Draw a simple labelled diagram of a cross-section of a solar cell.
On your diagram draw arrows to indicate the direction of the electron flow when sunlight falls on the cell.

★★★

CHEMICAL ENERGY

Of all the forms of energy, none is so useful and vital to the life of man as chemical energy. Much of this importance stems from its tremendous versatility.

Sometimes, as in ordinary fuels such as coal or wood, the chemical energy is so readily given up that a lighted match is all that is needed to release it. But there is also latent chemical energy in a diamond which does not burn until it is heated to 650°C.

Chemical energy can be controlled so easily that we can use it to toast meringues. Yet it can be explosively uncontrollable as in a bomb. The pages of a book slowly release chemical energy as they combine with oxygen in the air. The pages slowly yellow as a result of this slow "burning". In contrast, the five strands of metal in a photographic flash bulb burn almost instantaneously in a blinding flash of light.

Chemical energy is released when the chemical bonds that hold matter together are rearranged. Atoms are tightly bonded together to produce molecules. Molecules are bound up into larger pieces of matter that are big enough to see and touch. An atom of oxygen, for example, will join in a firm partnership with two hydrogen atoms to form a molecule of water. And many molecules of water will incorporate to form raindrops, oceans and icebergs.

Every bonding between atom and atom, molecule and molecule is a potential source of energy.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? versatility (line 3), matter (line 16), latent (line 6), incorporate (line 19), potential (line 22).

2. What is the source of chemical energy?

3. What is the structure of a water molecule?

4. What is the difference between an atom and a molecule (lines 15 and 16 respectively). Give examples to illustrate your answer.

5. What is a chemical bond - describe briefly the various types of chemical bonds, using examples of compounds which contain each.

6. The passage says "chemical energy is created when the bonds that cement matter together are broken". Strictly speaking this statement is incorrect. Why? What does it really mean to say?
   Can you see two mistakes in this sentence?

7. Give a brief description of 3 direct applications of man's use of chemical energy.

ANTOINE LAURENT LAVOISIER 74

Lavoisier's best known contribution to science is his demolition of the phlogiston theory. Phlogiston was thought to be an invisible substance present in all combustible materials and in metals. It was an all-purpose ingredient which was used to explain all sorts of chemical reactions.

The reason some substances crumbled to ash when burned was thought to be that phlogiston departed from them. The reason a *calx* (metallic oxide) turned back into metal when it is heated on a carbon block, was because phlogiston joined it from the carbon. Depending on the particular chemical reaction phlogiston could have weight, be weightless or even have negative weight. It was this aspect of the phlogiston theory which made some scientists uncertain and which eventually led to its downfall.

Using a very accurate balance Lavoisier performed a classic series of experiments. In one, he placed some tin in a flask, sealed it, weighed it, and heated it, until no more powdery calx "was formed'. He reweighed the flask and found no weight change. Then he broke the seal allowing air to rush in. He reweighed the flask and noticed an increase.

Lavoisier concluded that the increase was due to the weight of air rushing in when the flask was unsealed. This air had replaced original air which had been used up in forming the calx. Just what had been removed from the air in the calx forming process Lavoisier didn't know. Later, however, an experiment performed by Joseph Priestley gave him a clue.

Instead of forming a calx, Priestley unformed one. He heated red mercuric oxide. In the process he liberated a gas, which, as a confirmed phlogistonist, he labelled "dephlogisticated air". Lavoisier, collecting some of this "air" in a new experiment, found it to be what he sought. It was the one responsible for both combustion and for forming calx. He named it oxygen.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? combustible (line 3), balance (line 12), classic series (line 12), unformed (line 22), liberated (line 23).

2. Explain how Lavoisier's observations falsified the phlogiston theory.

3. What was meant by "dephlogisticated air"? (line 24)

4. One part of the phlogiston theory allowed phlogiston to have weight, be weightless or even have negative weight (line 9). Some scientists would be unwilling to accept this part of the theory. Why?

5. Use the phlogiston theory as the "phlogistonists" would have used it to explain these observations.
   (a) When heated in air, magnesium burns with a brilliant flame forming a powdery calx which is heavier than the original magnesium.
   (b) The calx formed from burning a log of wood has only a fraction of the original weight of the log.

RESEARCH QUESTIONS

6. Lavoisier is also credited with laying down the basic standard by which a substance could be tested to be an element or not. What is it?
7. How did Lavoisier die? What did Coffinhal have to say about Lavoisier's death?

GASES

Although more is known now about gases than either solids or liquids, gases were the last to be identified as a distinct state of matter. Until the seventeenth century, with its proliferation of scientific techniques and tools, gases remained hard to capture and analyse. They could not, like solids, be broken, bent or powdered. They could not, like liquids, be poured, soaked up, frozen or boiled.

The Greeks were the first to recognise that air had substance. In the fifth century B.C., the philosopher Empedocles noticed that a container, inverted in water did not completely fill with water. Empedocles concluded that air in the vessel resisted the influx of the water.

Satisfied that air had substance, the Greeks thought that it also had weight, but were unable to confirm this experimentally. One hundred years later, Aristotle decided that an empty space could not exist in nature. The convenient catch phrase "nature abhors a vacuum" sufficed for the next 2 000 years to explain the effects of weightiness of air in early siphons, bellows and pumps. In the 17th Century, Galileo provided the answer in a simple experiment which showed that air has weight. On his scales he balanced a sealed vessel containing nothing but air at normal atmospheric pressure against a heap of sand. Then he pumped more air into the vessel, resealed it and put it back on the scales. He found that it outweighed the sand. Galileo reasoned that the added weight could only be due to the increased amount of air inside the vessel.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? distinct (line 2), matter (line 2), proliferation (line 3), analyse (line 4), inverted (line 9), resisted (line 10), influx (line 10).
2. Why were gases the last to be identified as a state of matter?
3. What is meant by the phrase "nature abhors a vacuum" (line 14)?
4. From the article, work out in which century Aristotle lived?
5. Why was it not until Galileo's time that an experiment to show that air had weight could be devised?
6. List at least 3 differences between solids, liquids and gases mentioned in the article.
7. What steps did Galileo take in his experiment to show that air has weight.

RESEARCH QUESTIONS

8. What was a philosopher (line 8) in the 5th Century B.C.? Is a modern day philosopher the same sort of person? Name 5 other philosophers from the early days of science. Why were these people NOT called scientists?
9. Explain how either a siphon bellows or a pump could give an effect of weightiness of air (line 15). Use a diagram to show how the one you choose works.
10. What is normal atmospheric pressure (line 18)? How is this measured? Draw a diagram to show how this instrument works.
11. Atmospheric pressure as expressed as 760 mm of mercury or 101.3 kPa. Show how these are identical measurements.

SIZE OF GAS MOLECULES

Particles of matter are very small. They are also very close together. Or are they? Let us look at the molecules of a gas.

The radius of a small gas molecule is about 30 nm. One nm (nanometre) is 10^{-9} metres. The average distance between molecules is about 300 nm. This means that the distance between molecules is ten times their radius.

If one of these molecules was the same size as earth, the next molecule, also the same size as earth, would be 128 000 km away. This is about one third of the way to the moon.

In fact, if we look at this in terms of the space occupied by molecules - only $\frac{1}{1\ 000}$ of the available space is occupied by matter. This is 0.1%. In other words, 99.9% of the air you breathe is empty space! The size of these molecules can be emphasised perhaps if we know this: there are 26 868 300 000 000 000 000 of them in *one cubic centimetre* of space! And then, they only take up 0.1% of that space!

Why do the gas molecules stay so far apart? Why don't they gravitate together? The answer is that they possess energy which takes the form of rapid motion. This motion jostles the molecules apart.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? particles (line 1), matter (line 1), radius (line 3), average (line 4), gravitate (line 17), jostles (line 18).

2. How many "earth molecules" would fit between the earth and the moon? Draw a simple diagram to show this.

3. What is the distance between the earth and the moon?

4. How far apart, in centimetres, are the molecules of a gas?

5. What is the diameter of the earth?

6. How many air particles are there in one cubic centimetre of air? Express this number in scientific notation. Is cubic centimetre an acceptable unit for scientific use?

7. You have a 100 mL container of air. How much of this is empty space?

RESEARCH QUESTIONS

8. (a) Assume it was possible to have one cubic centimetre *completely full* of air molecules. How many air molecules would this cubic centimetre contain?

   (b) From your answer to (a) calculate the volume occupied by *one* air molecule.

9. Who first worked out how many molecules occupy a given space? Find out more about this scientist. What other work did he do?

10. What did the following scientists contribute to the study of the sizes of particles?
    (a) Amedeo Avogadro
    (b) James Clerk Maxwell
    (c) Ludwig Boltzmann

SOURCE: New Horizon Library - Atoms and Energy ★

77a

WHAT ARE ATOMS MADE OF?

If we could look inside the atom, we would spot a tiny, solid body lying at its centre. This body - the *nucleus* - is only one ten-thousandth the size of the atom. Between it and the electrons at the outside is empty space. Although the nucleus is so small, it is several thousand times heavier than the electrons that move around it.

The electric charge on each electron is called a *negative* charge. The nucleus has several *positive* electric charges. In fact, the number of negative charges on the electrons is normally equal to the number of positive charges on the nucleus. The positive and negative charges cancel each other out, so the atom as a whole normally has no overall electric charge. But when an electric current flows, electrons move among atoms, producing a movement of electric charge. A flash of lightning happens when great differences in electric charge build up between atoms in the air.

It is a basic law of electricity that like charges repel each other and unlike charges attract. This explains why atoms can make up solid objects, even though they consist mainly of clouds of electricity. If two atoms closely approach each other, the electrons at the outside of each atom repel each other because they have the same negative charge. The closer they approach the more strongly they push each other apart. It is impossible for one atom to move inside another. Forces other than electric forces keep the atoms together in the arrangements that make up solids and liquids.

The nucleus of an atom is in fact not completely solid. It is made up of smaller particles grouped tightly together. One of these particles is called the *proton*. It has one positive electric charge, and is nearly 2 000 times heavier than an electron. The total number of protons in the nucleus normally equals the number of electrons. This is why the positive and negative charges in an atom are usually equal in number. The simplest atoms have a nucleus of one proton surrounded by one orbiting electron. These atoms are hydrogen atoms.

All the other elements apart from hydrogen contain another kind of particle in the nucleus of their atoms. This particle is called the *neutron*. It is almost exactly like the proton, except that it has no electric charge. An atom of carbon, for example, has six electrons and therefore its nucleus contains six protons. But the nucleus also has six neutrons.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   cancel (line 9), basic (line 15), law (line 15), arrangements (line 22).

2. What causes two atoms to repel each other?

3. Draw a diagram showing the structure of a carbon atom. Label each part.

4. If the nucleus of an atom was one millimetre across, how far away from it in metres would the last electrons be, according to the information given in the passage.

5. Why does an atom normally have *no* overall electric charge?

6. A sodium atom has 12 neutrons and 11 electrons. How many protons does it have?

7. Copy and complete the following table from the information found in this article?

Name of Particle	*Charge on Particle*	*Where in atom it is found*	*Relative mass of Particle (Proton = 2 000)*

RESEARCH QUESTIONS

8. What is an electric current (line 11)? How is it formed? Why do some substances conduct an electric current, while others do not?

9. Find out the name of the scientist who discovered the basic law of electricity. (paragraph 3)

Source: New Horizons Library - Atoms and Energy. ★★

78a

WHAT ARE ATOMS LIKE?

It is difficult to grasp the idea of something as small as an atom. If we say that 250 000 million them go to make up the full stop at the end of this sentence it really means very little to us. Perhaps the best way is to imagine an atom enlarged to the size of something you know, and then to consider how big other familiar objects would be in comparison. For example, if the smallest atom were the size of the nail on your little finger, then your hand would be as big as the world! That gives you a rough idea of the size of the smallest atom. It is in fact a hundred-millionth of a centimetre across. Even the largest atoms are not much larger than this.

The Arrangement of Atoms. We do not really know what an atom looks like. It is possible to take pictures of large atoms through special microscopes, but the pictures show only white blobs. It is not, in fact, important what an atom looks like. The atoms in an object would not look like the small pieces of the object. A hydrogen atom from a sample of red paint would appear just the same as one from colourless water. The appearance of anything depends on the way the atoms are arranged, rather than the actual appearance of the atoms themselves.

The arrangement of atoms or molecules in anything also determines whether it is a gas like the air, liquid like water, or solid like the chair on which you are sitting. There are forces between the atoms or molecules that pull them together. In a solid, the forces are strong and the atoms or molecules pack tightly together. It is difficult for the atoms or molecules of anything else to enter the tight arrangement in a solid, so solids are strong enough to support themselves and often other objects too. In a liquid, the forces are not so strong and the atoms or molecules have a loose arrangement. The liquid can flow to take up any shape and other objects can move through it. In gases, the forces are very weak and the gas atoms or molecules are not arranged in any way. They can move apart until the gas fills its container.

Heat Makes Atoms Vibrate. We can change a solid into a liquid and a liquid into a gas by heating it. The solid melts and the liquid boils. This happens because heat reduces the forces linking the atoms or molecules. The atoms or molecules are always vibrating, even in the tight arrangement of a solid. The hotter they get, the more they vibrate. If a solid is heated enough, the atoms or molecules vibrate so much that the arrangement becomes loose and the solid melts to liquid. If the liquid is heated sufficiently, the atoms or molecules move more and more and break away from the arrangement. The liquid boils and becomes a gas, In a gas, the atoms or molecules are flying about at random in all directions.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

grasp (line1), atom (line 1), microscopes (line 12), molecules (line 19), determines (line 19), random (line 40).

2. Using the information in this article copy and complete the following table:

State of matter	*Relative strength of forces holding molecules together*	*Arrangement of molecules in states of matter*

3. Briefly describe, in your own words, what happens to the atoms of a solid as it is changed into a liquid and then into a gas.

4. In paragraph two we are told that "we do not really know what an atom looks like". Why not?

5. What is it that gives colour to substances?

6. What would we have to do to a gas in order to change it into a liquid?

7. (a) Express a hundred-millionth of a centimetre (lines 8 and 9) in metres
   (i) as a decimal.
   (ii) in scientific notation.

   (b) How many atoms lying side by side would be needed to form a row 1 metre long?

RESEARCH QUESTIONS

8. (a) What is (i) the smallest atom known?
   (ii) the biggest atom known?

   (b) Exactly how big, in metres, is each of these.

   (c) Arrange the atoms of these elements in order of smallest to largest.
   sodium, potassium, lithium, fluorine, chlorine, bromine, iodine, lead, copper, iron.

9. Draw a labelled diagram of an atom showing all its parts. How does a hydrogen atom differ from an oxygen atom?

10. Why would the atoms in an object *not* look like small pieces of the object? (see paragraph 2). Give examples to illustrate your answer.

SOURCE: New Horizon Library : Atoms and Energy ★★★

HOW DO ATOMS JOIN TOGETHER? 79a

The main substances we use that are elements are the oxygen we breathe in the air; some metals, especially aluminium; and carbon in the form of fuels such as coke. Almost all the substances we use in our everyday lives - such as water, salt, wood, cloth, food and medicines - are made of compounds rather than elements. To make compounds, atoms of different elements must join together. This can happen in two ways.

Atoms can gain or lose electrons to form ions. If an atom gains an electron, it also gains the negative electric charge of the electron. It becomes a negative ion. If an atom loses an electron, it loses the negative charge and becomes a positive ion. Because unlike electric charges attract each other, a negative ion and positive ion will be pulled together, rather like the way a magnet attracts iron. A bond called an *ionic bond* forms between the two atoms. Many atoms can join together in this way to make up a tight arrangement of atoms.

The other way in which atoms can join together is by sharing electrons rather than by exchanging them. When an ionic bond forms, one atom gives one or more electrons to another atom. The electrons move from one atom to the other. But in many compounds, electrons are given by both the atoms that join. The electrons move around both atoms, forming a bond called a *covalent bond*. In some kinds of covalent bonds, the electrons come from one of the joining atoms instead of from both.

When ionic bonds form, the electrical attraction can bring any number of atoms together in a great arrangement of atoms. The arrangement has no set size, and more atoms can simply join on to it if necessary. But when covalent bonds form between atoms, a definite group of atoms join together. If there are more atoms around, they form separate identical groups. These groups are called *molecules*. We therefore find molecules in covalent compounds, but not in ionic compounds.

The way in which atoms join to make a compound may give the compound a certain shape. Salt, for example, is always found as cube-shaped crystals. The salt crystals in a packet of salt are very small, but it is possible to grow large cube-shaped crystals of salt. The crystals have a cubic shape because the atoms in them are joined togher in a cube-shaped network.

But we cannot always grow crystals of substances to find out how the atoms are arranged inside them. Instead scientists pass a beam of X-rays through a substance. The beam is split up by the atoms in the crystal and produces a pattern on a photographic film. From the pattern, scientists can tell how the atoms are arranged in the crystal. In this way, they found that the huge molecule of DNA consists of two long chains of atoms shaped like two spiral staircases winding around each other. It is these complicated DNA molecules that pass on all heredity information from one generation of living cells to the next.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR ONW PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? elements (line 1), compounds (line 5), atoms (line 7), bond (line 19), molecules (line 27).

2. What is an ion (line 7)? Explain how the different types of ions form.

3. What are the differences between ionic bonds (line 13) and covalent bonds (lines 19 and 20)?
You could summarise your answer in the form of a table.

4. Why do we find molecules in covalent substances, but not in ionic substances?

5. What gives crystals their characteristic shapes?

6. Draw up a table which shows ten different compounds, and the following information: Formula of the compound, elements in the compound, are the elements joined by ionic or covalent bonds, is the compound ionic or covalent?

7. The article states that ions are held together because unlike electric charges attract each other (lines 10 and 11). Using the compound sodium chloride as an example, show how the ions form and why they attract each other.

8. Write a short explanation of how X-rays are used to determine the structure of a crystal. Are there any other ways of finding out this information?

9. (a) What do the letters DNA stand for?

   (b) Who discovered the structure of DNA? When?

   (c) Why was this discovery a breakthrough in biological science?

SOURCE: New Horizon Library : Atoms and Energy ★★

KINDS OF ATOMS

80a

There are only about a hundred different kinds of atoms, yet they combine together to make up everything in the universe.

Atoms are made up of nuclei containing protons and neutrons, around which electrons move. One atom is therefore going to be different from another if it contains different numbers of these particles. Substances that contain only one kind of atom are known as *elements*. Hydrogen, oxygen, carbon and chlorine are elements. So are metals such as mercury, copper, sodium, gold, silver and uranium. An atom of one element is different from an atom of another element because it has a different number of protons in its nucleus. A hydrogen atom has one proton, a carbon atom six and an oxygen atom eight, for example. Altogether 105 different elements are known. But some of these are not found in nature because they change into atoms of other elements very quickly. They can be made artificially, but have a very short life. Less than 100 elements are found in nature, and the whole universe is made up of them.

But the universe obviously contains many thousands of different substances, and not only a hundred or so elements. This is because most substances consist of combinations of two or more elements. They are called *compounds*. As there are thousands of possible combinations of elements, there are thousands of different compounds. The electrons in the atoms are involved when atoms come together to make compounds. Atoms may gain or lose electrons. This does not make any difference to the identity of the element. It is the number of protons in the nucleus that matters, and this number is called the *atomic number*. Each element has its own atomic number. Hydrogen is 1, carbon 6, oxygen 8, and so on. If an atom were to lose or gain protons, it would become an atom of another element because its atomic number would change.

What happens if the number of neutrons in the nucleus changes. In fact, very little happens. The atom is exactly the same except that it is a little lighter or heavier. An element looks and behaves identically however many neutrons its nuclei contain, as long as its behaviour does not involve the nuclei. Making compounds does not involve the nucleus, nor does the appearance of an element. In fact, many elements that occur in nature are mixtures of atoms containing different numbers of neutrons. Chlorine, for example, is a mixture of atoms containing 18 or 20 neutrons per nucleus. The chlorine nucleus has 17 protons, so that nuclei of chlorine contain 35 or 37 particles.

Atoms of an element that contain different numbers of neutrons are called *isotopes*. Chlorine is made up of two isotopes. They are called chlorine-35 and chlorine-37.

Some elements occur in nature as only one isotope. Natural aluminium, for example, is made up of only aluminium-27. Other elements are mixtures of two or more isotopes. Tin, for example, occurs as a mixture of ten isotopes. But many more isotopes of all the elements can be made artificially. These isotopes do not occur in nature because they always break down into atoms of other elements.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? elements (line 6), artificially (line 13), compounds (line 19), nucleus (line 23), mixture (line 34), isotope (line 39).

2. At the end of paragraph one, it is stated that the universe is made up of less than 100 elements. What assumption have scientists made which allows them to say this?

3. What causes one element to be different from another? Why is sodium different from magnesium?

4. (a) If a uranium atom lost a neutron, it would still be a uranium atom. However if it lost a proton, it would no longer be a uranium atom. Explain why.

   (b) What would a uranium atom be if it lost a proton?

   (c) What would a uranium atom be if it lost
   (i) an electron, (ii) two electrons?

5. What is the atomic number of chlorine? What evidence in the article enables you to answer this question?

6. How many (i) protons and
   (ii) neutrons in an atom of a) chlorine-35
   b) chlorine-37?

7. In each of the following cases state whether or not a *new* element would be formed? Explain your answers.
   (i) A hydrogen atom loses an electron.
   (ii) A sulphur atom gains two electrons.
   (iii) A carbon atom gains two neutrons.
   (iv) A uranium atom loses 2 protons.

8. (a) What is meant by chlorine-35 (line 40), chlorine-37 (line 40) and aluminium-27 (line 42).

   (b) What do the numbers mean, and how are they obtained?

RESEARCH QUESTIONS

9. Sodium-23 has an atomic number of 11. How many protons and neutrons are contained in the nucleus of an atom of sodium-23?

10. When was this article most probably written?
    (a) 1960 (b) 1965 (c) 1970 (d) 1975
    Explain your answer including evidence from the article.

11. (a) What is atomic mass?

    (b) Divide all the elements mentioned in the passage into metals and non-metals. Alongside each write its atomic number, how many protons, neutrons and electrons an atom of each element has and the atomic mass of each.

12. Name 5 compounds and the elements which combine together to form them.

13. Name 5 other elements which have isotopes. List the isotopes along with their atomic numbers, and atomic weights.

14. Protium, Deuterium and Tritium are the only isotopes with their own names.
    (i) of which element are they isotopes?
    (ii) why were they so named?
    (iii) what is the common name for Deuterium oxide.
    (iv) for what reason is Deuterium oxide used in the nuclear industry?

SOURCE: New Horizon Library: "Atoms and Energy" ★★★

CONTROLLING THE ATOM

81

An atom bomb explodes because a chain reaction multiplies and gets out of hand. Each fission of an atom produces neutrons that cause two or three more fissions, which produce more neutrons that cause even more fissions and so on, all in a fraction of a second. But if the chain reaction is slowed so that only one neutron from a fission causes another fission, then the reaction proceeds steadily and does not multiply. This happens in a nuclear reactor. It is made so that a runaway chain reaction and a nuclear explosion are impossible.

In natural uranium, only one in every 140 atoms is uranium-235. The other atoms are uranium-238, which does not produce fission when struck by neutrons. A chain reaction does not occur in natural uranium because there are not enough uranium-235 atoms to keep it going. A fission of a uranium-235 atom may occur, but the neutrons produced will most probably be absorbed by the uranium-238 atoms. Also, the fission produces fast-moving neutrons, which tend to bounce off uranium-235 atoms. Further fission is much more likely to happen if the neutrons move more slowly. A nuclear reactor can therefore work if the natural uranium is treated to increase the amount of uranium-235, and if the neutrons produced are slowed down.

The fuel for reactors therefore usually consists of *enriched* uranium or uranium compounds, which contain a higher proportion of uranium-235. The fuel is placed in long tubes, which fit into the *core* - the centre of the reactor. To help make the chain reaction go, a *moderator* is placed around the fuel to slow the neutrons produced by fission of the fuel. The moderator is usually graphite or water. In case the chain reaction starts to go too quickly, *control rods* are also inserted into the core. They are made of metals such as cadmium or boron that absorb neutrons and can be moved in or out of the core.

As the chain reaction proceeds steadily in the fuel, heat is produced. If the core gets too hot, the control rods are pushed in to take up some neutrons and slow the chain reaction. The reactor cannot explode, but it can get dangerously hot. In this case, the control rods can be pushed right into the core to stop the chain reaction. The core is surrounded by a thick layer of concrete to stop radiation and neutrons from escaping and harming people. This is called a *biological shield*.

A cooling liquid or gas passes through tubes in the core to take up the heat. This heat can then be used to produce steam which, in turn can be used as a source of power.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   fission (line 2), neutrons (line 3), natural (line 9), enriched (line 19), radiation(line 33).
2. How is a chain reaction (line 1) produced?
3. Explain how a chain reaction is prevented from getting out of control in a nuclear reactor.
4. Why doesn't a chain reaction occur naturally in uranium?
5. What are the conditions required before a chain reaction will occur?
6. Explain the function of the following parts of a nuclear reactor.
   moderator (line 22), control rods (line 25), biological shield (line 34), cooling liquid(line 35).

★★★

THE DISCOVERY OF X-RAYS

82

In 1895 X-rays were discovered by William Konrad Röntgen, a physics professor at the University of Wurzburg in Germany. He was working with a cathode tube in which a current of electricity was passed through a vacuum from one terminal inside the tube to the other. Because such a tube glows slightly when the current flows, Röntgen had darkened the room to see the glow better. Suddenly he noted that a piece of nearby glass covered with a barium salt also glowed whenever the tube was operating. This occurred even though the glass was screened from the apparatus by a piece of black paper. He put a book in front of the tube and the glass still glowed. Then he substituted a piece of wood, and finally a piece of aluminium. The rays penetrated everything, including his hand. Furthermore, when he held his hand between the cathode tube and a photographic plate, the skeletal image was left on the plate. Röntgen's discovery created as much flurry in the press of his day as did the moon landing in modern times. More than 1 000 scientific articles were published on the new X-rays in just the first year of its discovery.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?

   vacuum (line 3), terminal (line 4), apparatus (line 8), image (line 13).

2. How were X-rays discovered?

3. Name 4 substances which are able to be penetrated by X-rays.

RESEARCH QUESTIONS

4. What is a barium salt (line 7)? What is a salt in chemistry? Name and give the chemical formulae for 3 barium salts.

5. What is a cathode ray tube? Draw a labelled diagram of a cathode ray tube. List 5 uses man has for cathode ray tubes.

6. What was Röntgen trying to do when he accidentally discovered X-rays?

7. How are X-rays produced these days? What uses do they have in our modern society?

8. Why is it important for pregnant women not to have X-rays? Are there any other dangers associated with X-rays?

SOURCE: Life Science Library : Matter ★★★

DISCOVERY OF THE INERT GASES 83a

Helium and gases related to it were hard to find and difficult to liquify. Called *inert* or *noble* gases because they "snubbed" other elements, they were tracked down in one of the great sagas of chemical detection.

Their trail was picked up in 1785 when Henry Cavendish, in an experiment with air, noticed that a small bubble, about 1/120th of the whole, would not take part in the chemical reaction. The importance of this observation was not realised for over 100 years.

In 1868, a French astronomer, Jules Cesar Janssen noticed a brilliant yellow line in the sun's spectrum. It was attributed to an unknown element, which was named helium after *Helios* the Greek word for the sun. Thirteen years later, an Italian Luigi Palmieri detected the same line in the effluvia of the crater of Vesuvius. An American chemist, William Hillebrand, subsequently isolated an inert gas with the same spectrum from a uranium mineral.

In 1894, two English men, J.W.S. Rayleigh and William Ramsay observed a mysterious gas in the air and analysed it with a spectroscope. This device identifies gases by the characteristic colour lines they show when an electric current passes through them. The gas, which seemed to have no chemical properties at all, revealed red and green lines never observed before. Rayleigh and Ramsay named it argon, "the lazy one".

From all the accumulated data, Ramsay then identified helium. In 1898 he discovered krypton, neon and xenon by liquifying air and examining the residue left when the oxygen and nitrogen were evaporated. The last inert gas, radon, was discovered by Ernst Dorn, a German, in 1900.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? liquify (line 2), snubbed (line 2), sagas (line 3), element (line 11), effluvia (line 13), analysed (line 17), characteristic (line 18), properties (line 20), accumulated (line 22), residue (line 24).

2. What technique enabled the inert gases to be observed and identified?

3. How were samples of the inert gases obtained?

4. What is meant by the expression "called inert or noble gases because they "snubbed" other elements (lines 2 and 3)?

5. Why was it difficult to isolate and identify the inert gases until over 100 years after they were first noticed?

6. Why did Ramsay refer to argon as a mysterious (line 17) gas?

7. Draw up a table listing the inert gases and their dates of discovery.

8. In which year was helium first detected and identified on earth?
   Suggest a possible reason to account for the time lapse between the discovery of helium in the sun and its actual discovery on earth.

RESEARCH QUESTIONS

9. Draw up a table of the inert gases listing the derivation of their names and what each means.

10. (a) What is a spectrum (line 10)?

    (b) How is a spectrum obtained?

    (c) To what uses is spectroscopy put today?

11. The inert gases are often referred to as the "rare" gases. Find out how much of each gas exists in our atmosphere.

12. In recent years some compounds of the inert gases were made. What are some of these and when were they first made?

★★

ACIDS

84

Acids are among the most useful and sometimes the most dangerous of chemical substances. Strong hydrochloric acid, for example, is a deadly poison, but if people did not have a small quantity of this acid in their stomachs they would not be able to digest their food properly.

The word *acid* comes from the Latin word *acidus* which means "sour", because most acids have a sour taste. A way of finding out whether a liquid is an acid is to pour a little of it over some blue vegetable colouring matter, called litmus. If the liquid is acid the blue litmus will turn red.

Many people think that acids are corrosive or "burning" liquids. This is because the two most common acids - sulfuric acid (oil of vitriol) and nitric acid (*aqua fortis*) are very corrosive and burn skin, wool and cloth. However, many acids are not as corrosive as this, and many are solids, not liquids.

Although some acids cause serious burns and some are deadly poisons, others are harmless and even good to eat. Many of these take their names from the fruit or substance in which they are found. Citric acid comes from citrus fruits, malic acid from apples, tartaric acid from grapes and acetic acid is found in vinegar.

Acids which come from plants and animals are called organic acids, but not all are pleasant. For example oxalic acid (in rhubarb), and prussic acid (in bitter almonds and peach stones) are very poisonous.

Sulfuric, hydrochloric and nitric acids are the most important inorganic acids and they are used to make batteries, fertilisers, explosives and plastics.

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1. What do these words mean as they are used in the passage?
   vegetable (line 7), corrosive (line 9), organic (line 19), fertilisers (line 23).
2. How could you determine whether or not a liquid was an acid?
3. Although many acids are not corrosive, why do most people consider them so?
4. What is the main difference between organic and inorganic acids?

RESEARCH QUESTIONS

5. The origin of citric (from citrus fruits) is obvious, but what does malic have to do with apples, tartaric with grapes, and acetic with vinegar?
6. How are these acids made industrially?
   (i) sulfuric acid
   (ii) nitric acid
   (iii) hydrochloric acid.
7. Describe in detail the uses of either hydrochloric or sulfuric acid.
8. Prussic acid is very interesting historically. For what purposes has it been used? What is its chemical name? What relation is there between prussic acid and Prussian blue?

★★

ALKALIS

85

Certain substances, which are called bases, can neutralise acids. This means that when they combine with acids, they form a salt and water. A base which dissolves in water is called an alkali. It will turn red litmus solution blue.

The word alkali comes from an Arabic word meaning ashes. People who lived a long time ago used the ashes of wood and seashore plants to make alkalis. Today alkalis are made in chemical factories.

Alkalis usually feel slippery and have a bitter taste. The strongest of them, called caustic alkalis, have a corrosive burning action on the skin and must be used very carefully. The most common alkalis are sodium, potassium, calcium and ammonium hydroxide, (Caustic soda, caustic potash, slaked lime and household ammonia respectively.

Caustic soda is one of the most important alkalis. It is a white solid which dissolves in water. It is used in making soap and rayon, and it is also used in the cotton industry. Caustic potash is used to make dyestuffs and some kinds of soap. Slaked lime dug into acid soil makes it more fertile by neutralising the acids. Household ammonia helps to remove grease and is useful in many cleaning situations.

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1. What is the meaning of the following words as used in the passage?

   neutralise (line 1), dissolves (line 3), caustic (line 9), corrosive (line 9), slaked (line 12), fertile (line 17).

2. The passage mentions 5 properties of alkalis. List them.

3. Construct a two-column table. List the four alkalis mentioned in the passage in one column, and their uses in the second column.

RESEARCH QUESTIONS

4. What is neutralisation? Describe the process of neutralisation in detail, giving chemical equations.

5. Describe in detail the manufacture of one of the following: soap, sodium hydroxide, ammonia.

6. Find 5 other uses of sodium hydroxide and ammonium hydroxide not mentioned in the passage.

CELLULOSE

Cellulose is a word meaning "made of cells". It is a substance found in nearly all plants. The softer parts of plants such as the pith in the centre of the stem, are made up of cellulose. It makes plants pliable so that they can be bent without breaking.

Cellulose is made of carbon, hydrogen and oxygen. These elements are obtained by the plant from the air and water. The plant makes sugars which flow through every part of the plant as sap. This helps in growth and repair. Part of the sugar in the sap is changed to cellulose and used for making the walls of new cells and for repairing parts of the plant that have been injured.

Many foods have a lot of cellulose in them. Foods such as lettuce, celery and bran contain cellulose. Animals such as the goat and the camel have certain bacteria in their stomachs which help them to digest cellulose. The human stomach, however, doesn't have these bacteria, so we cannot digest cellulose. It is useful to humans as roughage.

Only nature can make cellulose. Man cannot make it. Man uses it in many different ways, because it is a valuable raw material. It is used to make cotton, linen fibres, thread, rope and twine and thousands of other substances. It can be used to make explosives, photographic films, varnishes for wood and metal, rayon and plastics.

Large quantities of cellulose are made into paper, parchment and *papier mâché* and cardboard. Cellulose is quite durable: after a plant dies, it is one of the last parts to decompose. This property is one of the main reasons why it is so useful to Man.

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1. What do these words or terms mean as they are used in the passage?

   pliable (line 3), digest (line 12), raw material (line 16), durable (line 21).

2. For what reason(s) does a plant need cellulose?

3. Why is cellulose such a useful substance for Man?

4. What is the main use to which Man puts cellulose?

5. What is the pith of a plant? What does it consist of?

RESEARCH QUESTIONS

6. If cellulose contains the same elements as sugars, which are sources of energy for Man, why isn't cellulose a similar source of energy?

7. What is roughage (line 14)? Why is it useful to Man?

8. What is sap (line 7)?

9. What makes sap move through plants?

10. What is the connection between car tyres and sap?

11. List five other uses Man has for cellulose. Do not mention any from the passage.

12. What are the differences between thread, rope and twine (line 17 (line 17)?

13. What is *papier mâché* (line 21)? What is it used for? Where does the name come from?

SOURCE: Children's Britannica ★★

GELATIN 87

A pudding made from the hoofs, bones and horns of animals does not sound very tempting, but when it appears on the table as a jelly you probably enjoy eating it very much.

The gelatin from which such a jelly is made is obtained by first dissolving from the hoofs, bones and horns everything but the sticky substance called cartilage. The cartilage is then boiled until it dissolves. It is then a crude form of gelatin. Further refining and filtering in alcohol makes it a purer gelatin. This solidifies when cool and can be made into the powder or sheets sold as gelatin. When this is coloured and flavoured with fruit juices and then dissolved in warm water, it sets to a clear sparkling jelly on cooling.

Gelatin belongs to the protein class of foods so it is easily digested. It is used chiefly in jellies, and in soups, ice cream, chocolate fillings and preserved meats . It is also used as a coating for pills, and in cough sweets and throat medicines. Other uses include making glue and photographic films.

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1. What do these words mean as they are used in the passage?
   dissolving (line 5), crude (line 7), refining (line 7), filtering (line 7), class (line 12), digested (line 12).
2. Which part of the hoofs, bones and horns is actually used to make the gelatin?
3. Why is gelatin good for invalids? Give a second reason, not mentioned in the passage.
4. Why is gelatin used for so many foodstuffs?

RESEARCH QUESTIONS

5. Find out how gelatin is used to make photographic films.
6. In the manufacture of the gelatin, what is the purpose of the filtering in alcohol (line 7)?

★★★

SOURCE: Adapted from J. Bronowski, 'The Ascent of Man', 1976, pages 125-133.

COPPER AND IRON

88a

Almost ten thousand years ago, not long after the beginning of the settled communities of agriculture, men in the Middle East began to use copper. But the use of metals could not become general until there was found a systematic process for getting them. That is the extraction of metals from their ores, which was begun some seven thousand years ago, (5000 B.C.) in Persia and Afghanistan. At that time, men put the green rock malachite into the fire and from it flowed the red metal, copper. They recognised copper because it is sometimes found in raw lumps on the surface, and in that form it has been hammered and worked for over two thousand years already.

Metal became the backbone of civilised life. Man had at his control a material which can be moulded, drawn, hammered, cast; which can be made into a tool, an ornament, a vessel; and which can be thrown back into the fire and be reshaped. It has only one shortcoming - copper is a soft metal. As soon as it is put under strain, stretched in the form of a wire for instance, it visibly begins to yield. The coppersmith was faced with a robust problem, which is that copper will not take an edge.

The ancient smelters found an answer to this problem: namely, that when to copper is added an even softer metal, tin, an alloy is made which is harder and more durable than either - bronze. The working of bronze reached its finest expression in China. It had come to China almost certainly from the Middle East, where bronze was discovered about 3800 B.C. The high period of bronze in China is also the beginning of Chinese civilisation - the Shang dynasty, before 1500 B.C.

The proportions of copper and tin that Chinese used are fairly exact. Bronze can be made from almost any proportion between, say, 5% and 20% of tin added to the copper. But the best Shang bronzes are held at 15% tin, at that proportion bronze being almost three times as hard as copper. Bronze was used in making vessels for wine and food.

Because it is much more difficult to extract from its ores than copper, smelted iron is a much later discovery. The wide use of iron was initiated by the Hittites near the Black Sea around 1500 B.C. - just the time of the finest bronze in China, the time of Stonehenge.

Within five hundred years, by 1000 B.C., steel (the alloy of iron) was being made in India, and the exquisite properties of different kinds of steel came to be known.

Iron is a later discovery than copper because at every stage it needs more heat - in smelting, working and, naturally, in processing its alloy, steel. (The melting point of iron is about 1500 °C, almost 500°C higher than that of copper.) Both in heat treatment and in its response to added elements, steel is a material infinitely more sensitive than bronze. In it iron is alloyed with a tiny percentage of carbon, less than 1% usually, and variations in that dictate the underlying properties of the steel.

Being harder than either copper or bronze made steel superior especially in the making of weapons for these could then be used to more easily defeat opposing armies.

The sword, for instance, is the weapon of the Samurai. By it they survived endless civil wars that divided Japan from the twelfth century on. Everything about them is fine metalwork: the flexible armour made of steel strips, the horse trappings, the stirrups.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? agriculture (line 2), systematic (line 4), ores (line 5), cast (line 12), robust (line 17), alloy (line 20), durable (line 21), vessels (line 31), smelted (line 33).

2. For how long had man been using copper, before some way was devised for extracting it from its ore?

3. Why had metal become "the backbone of civilised life" (line 11)?

4. What evidence in the article indicates that copper is *malleable*?

5. What are some of the disadvantages of copper?

6. (a) What is bronze?
   (b) How did bronze overcome some of the disadvantages of copper?

7. Why was iron discovered at a later date than copper?

8. How many years passed between when copper was first extracted from its ores to when iron became widely used?

9. Fill in the blanks:
   (a) An ore of copper is _____.
   (b) Bronze is to copper as _____ is to iron.
   (c) Bronze contains copper and _____.
   (d) The melting point of copper is about _____^{0}C.

10. Why is steel "a material infinitely more sensitive than bronze" (lines 43 and 44)?

11. Why were iron and steel considered superior to copper and bronze?

12. What advantage would an army with steel weapons have over one which did not have steel weapons?

RESEARCH QUESTIONS

13. Describe how copper and iron are extracted from their ores today.

★★

SOURCE: Science as Part of Education, Aust. Sc. Tch. Jour., Vol. 10, No. 2, August, 1964.

SIR MARK OLIPHANT SAID THIS ABOUT LEARNING SCIENCE

89

"However the weaving of science into the cultural background of every man and woman will have far more important results than this. It will enrich the life and thought of every citizen, and will greatly increase his emotional involvement in the world in which he lives. Knowing how greatly men of every nation, creed and colour contribute to the advance of natural knowledge, he will be less conscious of the barriers of politics or of language than are those with knowledge only of their own particular culture. His respect for mankind as a whole will change the complexion of international and inter-racial relations. In short, science offers the best hope of collaboration between all peoples in common enterprise for the good of all. It is the greatest civilizing influence of all time, the natural bulwark against war, as well as by far the most important activity relieving mankind of famine, want and drudgery."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in this article? weaving (line 1), creed (line 5), culture (line 9), complexion (line 10), collaboration (line 11), bulwark (line 13), want (line 15).

2. What do you think Sir Mark Oliphant meant by the word *"this"* when he said "the weaving of science ... will have far more important results than this." (lines 1 to 3)?

3. What are the benefits, as seen by Sir Mark Oliphant, of studying science?

RESEARCH QUESTIONS

4. Do you agree with Sir Mark Oliphant's view? Explain what you think of the value of studying science.

5. Do you agree with the statement, "science offers the best hope ... for the good of all." (lines 11 and 12)? Explain your view.

HOW DO SCIENTISTS EXPLAIN ELECTRICITY? 90

A perspex rod is believed to be made of an equal number of positive and negative charges. This makes the rod normally neutral. The negative charges are called "electrons" and when the rod is rubbed with silk, the electrons are transferred from the rod to the silk. This makes the rod positively charged, because it now has more positive charges than negative charges. The electrons are small, even smaller than atoms, so that we do not see them being transferred. An ebonite rod behaves in a similar way when it is rubbed with a flannel. But this time, electrons are transferred from the flannel to the ebonite and the ebonite becomes negatively charged.

Now an electric current is believed to be a flow of electrons along a wire. Of course, no flow is possible without a circuit and no flow is possible unless there is a power source to provide a voltage. Sometimes, we can imagine a current in a wire to be like water in a tube. No water will flow unless we have a pump, and no current will flow without a voltage. That is, we can think of voltage as an electrical pump and we are measuring the pressure of the pump when we measure voltage with a voltmeter. Similarly, we can imagine we are measuring the amount of water flowing when we measure the current with an ammeter.

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1. Explain the meaning of each of the words underlined in the passage:

   neutral (line 2), transferred (line 4), similar (line 7), possible (line 11), circuit (line 11), source (line 12).

2. Which kind of rod is rubbed with silk?

3. Which kind of rod has a negative charge?

4. What do we call a flow of electrons along a wire?

5. What is needed before a current will flow?

6. What do we measure voltage with?

7. What do we measure with an ammeter?

8. What can voltage be thought of as?

RESEARCH QUESTIONS

9. What is an electron?

10. Thinking of electric current as water in a pipe is called an analogy. What is an analogy?

SOURCE: "Energy", Life Science Library, 1965. ★★★

MEASURING FORCE 91a

Leibnitz, in his attempt to work out some yardstick for the measurement of force, turned to Galileo's experiments with falling bodies. The Italian had found that all objects fall at the same speed no matter how big or heavy they may be. However, Leibnitz realized that an object weighing a tonne would do a lot more damage when it hit the ground than one weighing a kilogram. Here was a way to measure force. Simply work out a way to measure how big an impact an object will make. It is obvious, Leibnitz said, that the impact depends on two things - how much the object weighs and how far it falls.

But suppose you are not interested in the force exerted by a *falling* object. Suppose the object you are interested in is rising into the air, or rolling along level ground. Where does height fit into this? Leibnitz realized that it wasn't really the height that was important. It was how fast an object was falling. This of course is related to the height from which it falls. The further it falls, the faster it goes. Leibnitz modified his formula to say that the measurement of force depended on the weight of an object and how fast it was going when it was stopped.

He invented a name for the impact. He called it the *vis viva*. At the same time, Christian Huygens was pursuing a related line of inquiry. He spent tedious hours studying what happened when two moving objects collided. In 1699, the results of his observations were published. He declared that in a collision such as might take place between two perfectly hard billiard balls, the sum of the *vis viva* in each of the balls is the same before and after impact. One ball might be slowed by the collision but the other would be speeded up. The sum of the two *vis vivas* would always be the same.

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1. What do these words mean as they are used in this article? yardstick (line 1), speed (line 3), force (line 6), impact (line 7), modified (line 16), tedious (line 21).

2. How did Leibnitz measure force?

3. What caused Leibnitz to modify his formulae (line 16)?

4. The expression weighing a tonne (line 5) is actually wrong. Why is it incorrect and what is a correct statement in this case?

5. In the situation described, was it essential that the colliding objects be like perfectly hard billiard balls (line 24)? Explain.

6. What, in modern day terms is *vis viva* (lines 19 and 24)?

7. Leibnitz could be talking about kinetic energy or momentum or both. What is he talking about? Given evidence from the passage which enables you to make this implication.

8. The sum of the two *vis vivas* would always be the same (lines 26 and 27). Restate this in a more familiar form.

9. Is Leibnitz correct when he says that the force exerted by a falling object depends on <u>how much the object weighs and how far it falls</u> (lines 8 and 9). Support your answer with physics you have studied. Is this really the same as the *vis vivas* of Leibnitz? Explain your answer.

SOURCE: The Bulletin, 1978, date unknown. ★★

THE REALITY OF THE SMILING AUSTRALIAN

92a

What is in the Australian smile? Fifteen million rotting and decayed teeth for starters, two million cases of mild or serious gum infection and two million sets of false teeth according to the experts.

The dental professional remains gloomy about the statistics. For years they've been trying to convince people that apples, carrots and celery don't clean the teeth, that religious scrubbing is not the answer to tooth decay and that fluoride does have benefits for everyone over the age of 12.

The Dental Health Education and Research Foundation at the University of Sydney has also been trying to convince people that dentists can guarantee 100 percent protection against cavities, provided that patients follow certain rules. These are cleaning teeth properly, using dental floss, and special soft tooth picks daily and a special paste once a week. The floss and tooth picks are necessary because toothbrushes cannot reach effectively into the cracks between the teeth. If you care for teeth by this approved method, don't eat sweets and visit a dentist regularly, your teeth should remain faithful for life.

Even if a tooth becomes dislodged or lost during an accident, it can be saved by placing it immediately back into the socket. If it is put back within 30 minutes, there is a 90 percent chance of it being saved, because the fibres attaching it to the bone re-attach themselves in a natural healing process. The longer the delay, the less chance of saving the tooth. If it hasn't been replaced for two hours, it has only a 5 percent chance of being saved.

If, however, the stage of prevention is past, cure is still possible. Dentists are perfecting tooth implant operations for people who can't or won't wear dentures, magnetic false teeth for those who can and will, and cosmetic remodelling for people who just want a nicer smile.

The tooth implantation method is being pioneered around the world. One such method uses thin blades of titanium which are placed in grooves cut in the jawbone. If the operation is skilfully performed, the bone grows back around the titanium bracket, keeping it firmly in place. The gum also grows back and the false teeth are cemented into and between prongs or posts which are the only extension of the bracket into the mouth. Implants are costly and sometimes rejected, but they can be a boon to people who have trouble with dentures.

Magnets are being used to solve the problem of loose dentures. Dr. B.R. Gillings, a senior lecturer in the Department of Prosthetic Dentistry at the University of Sydney, has fitted patients with dentures held in place by tiny strong magnets. This method, because of its low cost and simplicity, can be used in cases where more expensive and complicated attachments are unsuitable.

Then there is cosmetic dentistry, which is expensive, but rapidly growing in popularity. Thousands of Australians are paying up to $5 000 to have naturally crooked or stained teeth capped or crowned in search of the good looks ideal.

But one word of warning about modern dentistry. New techniques and equipment have increased the risk of accidental injury and infection to patients. Possible hazards include lacerations, flying fragments disappearing down the patient's throat, or landing in the dentist's eye.

New furniture which enables the dentist to work seated increases the risk of instruments falling into unlikely places. The *Medical Journal of Australia* reported in July that suture needles, a burr, a drill, amalgam fillings, inlays and teeth have been recovered from the stomachs and lungs of dental patients.

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DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in this article? infection (line 3), religious (line 6), cavities (line 11), floss (line 12), implant (line 26), pioneered (line 29), titanium (line 30), prosthetic (line 38), laceration (line 49), suture (line 53), burr (line 53).

2. What do you think the author meant by the heading of this article, 'The Reality of the Australian Smile"?

3. What percentage of the Australian population wear false teeth?

4. What are the special rules people need to follow to have 100% protection against cavities?

5. What is "dental floss"?

6. Why should dental floss and tooth picks be used when cleaning teeth?

7. What should you do when a tooth is forced out of position in an accident? Why is it important that you act immediately?

8. What is "titanium"? Why is it used in dentistry?

9. What is the "tooth implantation method"?

10. When would magnets be used in dentistry?

11. What would dentists do in "cosmetic dentistry"?

12. Are modern techniques in dentistry absolutely safe? Explain, giving examples.

RESEARCH QUESTIONS

13. Amalgam is used extensively in dentistry; what is amalgam? What amalgam(s) are used in dentistry? Why are they used? What are some of the hazards associated with their use?

TWINS

★★★ 93

There are two different kinds of human twins: fraternal twins who develop from two separately fertilised eggs, and identical twins who develop from the same egg. In the last case, the fertilised egg splits completely apart as it doubles.

Fraternal twins are as much alike as ordinary brothers and sisters in a family. They have different complements of chromosomes. However, identical twins look alike and are the same sex. They have identical sets of chromosomes.

Sometimes identical twins are reared apart. This can happen when they are orphans and are separated at birth. In these cases, the twins are exposed to very different environments. However, these different environments act on the same hereditary background. Therefore the importance of heredity and the environment on human development can be studied.

If the twins have not been separated, a comparison between the two types of twins can be made. That is, the effect of the same environment on identical twins can be compared with the effect on fraternal twins.

In this way a lot has been learnt about the way twins behave. The studies indicate that identical twins do behave in very similar ways. The behaviour of fraternal twins is not as markedly similar. However, if identical twins are separated, their behaviour differs more than those of identical twins not separated.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   fraternal (line 1), fertilised (line 2), chromosomes (line 6), reared (line 9), exposed (line 11), environments (line 11) hereditary (line 12)

2. What is the difference between *fraternal* and *identical* twins?

3. What was the purpose of these studies?

4. Three experimental situations are described in the passage. For example, one was the effect of the environment on identical twins reared apart. What are the others?

RESEARCH QUESTIONS

5. Many studies have been made about the effect of schooling on intelligence. Some people argue that intelligence is mainly inherited. Others argue that intelligence is developed by schooling. Still others argue that it is a combination of both.
   Using psychology books, outline two investigations involving the use of fraternal and identical twins that inquire into this problem.

VITAMIN C CONTROLS PRICKLY HEAT

Australian soldiers serving in Malaysia in the 1960s faced a medical problem. Their white skin was not used to the tropical heat and they suffered many skin disorders. The worst disorder was prickly heat. This type of rash was also thought to lead to other skin disorders such as ringworm, impetigo and athlete's foot. Doctors working in the tropics believed that lack of sweating caused prickly heat. They were not sure how to best treat this problem but decided to experiment with large doses of harmless ascorbic acid (Vitamin C).

The doctors planned two experiments. In the first experiment they used sixty soldiers' children who had severe prickly heat. Thirty of these were given large amounts of Vitamin C for seven days. In this time twenty six were cured. The second thirty were given a placebo in place of the Vitamin C dose. Only six of these showed improvement.

In the second experiment, twelve Royal Australian Artillery volunteers serving in Malaysia were used. Prickly heat was induced by wrapping the limbs of these volunteers in polythene sheeting for 48 hours. The soldiers were then treated with ascorbic acid. Ten of them were cured.

Although this treatment worked well, doctors were not sure why this was so. They suggested that the vitamin C was excreted in sweat and that this prevented sweat gland fatigue. Until further research takes place, however, it cannot be certain that this is the right explanation.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   disorders (line 3), impetigo (line 5), placebo (line 12)
   induced (line 15), excreted (line 19) fatigue (line 20)

2. What caused the Australian soldiers to get prickly heat in the case of
   (i) the serving soldiers; and
   (ii) the volunteers.

3. In the experiments which were done, how many people were treated (total), how many were cured or showed improvement, and how many of those treated were not cured?

4. Three hypotheses have been made in the passage. Rewrite enough of each so that it can be identified.

5. What conclusion could be drawn from these experiments?

6. Where is ascorbic acid found naturally? Is it synthesised by man? See if you can find out its chemical structure and copy it out. Do you understand what this means? What do we use ascorbic acid for?

★★★

SCIENTISTS FIGHT NEWCASTLE DISEASE 95

Newcastle Disease Virus (NDV) affects the respiratory tract and the nervous system of poultry. The disease appears with strains varying from mild to severe strength. The severe strains kill up to 100% of infected poultry. This causes hundreds of millions of dollars damage annually throughout the world.

Laboratory experiments showed ultraviolet radiation (UV) kills NDV in a matter of seconds. Applied research was needed, however, before the full impact of UV treatment could be known. Two Israeli scientists, Perek and Heller carried out this research.

During the first days of their lives, baby chickens may withstand slight infection of NDV because they receive some antibodies from their immunised mother through the egg yolk. However they gradually lose these inherited antibodies. Until the age of 21-28 days, vaccination of chickens is pointless as they are not able to produce sufficient antibodies in their tissues to counter a massive infection. It is also possible that the immunity young chickens have inherited through their antibodies, might be affected by too early a vaccination.

Under normal conditions chickens may be exposed to massive infection from NDV being carried through the air from infected poultry up to 4 kilometres away. Perek and Heller decided to try and control NDV by using continuous radiation from UV lamps of 253 nm wavelength. In the experimental houses, chicks from 1-60 days old were subjected to continuous UV radiation while in the adjacent control room, no radiation was installed. In each of the rooms a cage containing NDV-infected birds was placed high on the wall. The birds in the cage sneezed and coughed, spreading the drops from their beaks all over the room. When they died, they were replaced by other NDV-infected birds. The experiment lasted 22-26 days until the control groups died by NDV infection. No birds in the radiated groups showed signs of the disease and none of them died.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? virus (line 1), strains (line 2), ultraviolet (line 6), antibodies (line 11), immunised (line 11), inherited (line 12), vaccination (line 13), radiation (line 21).
2. How is NDV communicated between chickens?
3. What reasons have been given for the failure of vaccination of chickens against NDV?
4. How was this particular experiment set up and controlled?
5. What conclusion could be drawn from the results of this experiment?
6. If vaccination didn't work well with chickens until they were 21-28 days old, why weren't they vaccinated after reaching this age?

RESEARCH QUESTIONS

7. What is the difference between *immunisation* and *vaccination*
8. Who first discovered the principles of immunisation and vaccination? Briefly describe the series of events or experiments which lead to the discoveries.
9. List 3 diseases in man which can be avoided, or at least lessened by
   (a) immunisation and
   (b) vaccination.
   How are the immunising or vaccinating chemicals for each of the diseases you mentioned obtained? Which scientists were responsible for the discovery or development of each?

★★

IMMUNITY TO DISEASE

96

At the beginning of the 18th century, Lady Montagu returned to England with some surprising news. While in Constantinople she had seen parents deliberately expose their children to the dreaded smallpox disease. This had not led to the children's death. Quite the opposite had occurred. The exposed children became immune to the smallpox. From this start, it was gradually realised that those who survived an infectious disease rarely caught that disease again.

How does the body develop this immunity to disease? When a disease attacks a body it is rather like a war. On the one hand there are the invaders. These are chemical components of the disease called antigens. On the other hand there are the body's defenders. These are called antibodies. The antibodies attempt to destroy the antigens. If they succeed the disease is conquered; the war is over.

Some infectious disease are very dangerous. These include diphtheria, poliomyelitis, whooping cough and tetanus. If they attacked and the body were not prepared, death or serious illness could result. To make the body ready you prepare it against each disease in advance. To do this you inoculate with vaccine. This puts the body in contact with a mild form of each disease. The body reacts by producing antibodies. These antibodies give immunity against future serious attack by that disease. Health authorities in Australia make such vaccinations readily available.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these mean as they are used in this article?

   expose (line 3), dreaded (line 3), immune (line 5), infectious (line 7), antigens (line 11), antibodies (line 12), inoculate (line 18), vaccine (line 18).

2. What observations led to the idea of immunisation?

3. How does the body combat disease?

4. Why is immunisation necessary?

RESEARCH QUESTIONS

5. What is the cause of each disease mentioned in the article. Describe how immunity to each is obtained.

6. What is the *Triple-antigen* which is given to all babies by health clinics in Australia?

7. Some medical authorities have suggested that immunisation can lead to over-confidence. If nobody has children dying of these diseases, then other people will not have their babies immunised. Find out:

   (i) How many babies in your area have been immunised;
   (ii) If possible, why they have not been immunised; and
   (iii) What is being done locally to encourage parents to act on this matter.

DIABETIC MICE AND HUMANS

Laboratory mice with hereditary diabetes resembling the human diabetes disease have been discovered. To have diabetes in full form, the mice must inherit the gene from both parents. Such mice, however, are infertile. Consequently a special ovary-transplantation technique has to be used to keep the diabetic mouse line from dying out. As the diabetic female's egg cells carry the diabetic gene, her ovaries are transplanted to a healthy female. This healthy female is then mated with a male that is fertile because he carries only one diabetes gene. About half the mice born of such matings carry two diabetic genes and consequently develop the disease.

At first the mutant mice appear to be normal but soon they get fat. In spite of fasting and losing weight, and so lowering their blood sugar levels, they soon regain weight and blood sugar levels once their food intake is restored. Later, as the disease becomes rampant, they lose weight drastically as happens with human diabetes. Between 3 and 6 months of age the mice enter a terminal phase and usually die.

There are other ways in which the animal disease parallels the human disease. These ways include sensitivity to stress, excretion of large amounts of sugar in the urine and abnormal changes in the pancreas.

Some of the diabetic mice have responded to insulin treatment but the proper dosage remains to be worked out. Attempts are being made to prolong the animals' lives so that degenerative changes in the pancreas and other organs can be studied. One animal has lived nearly a year. Most of them, however, die after six months.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? hereditary (line 1), gene (line 3), infertile (line 4), consequently (line 4), ovaries (line 6), mutant (line 11), rampant (line 14), terminal (line 16), insulin (line 21), degenerative (line 23).
2. What are the symptoms of diabetes in mice?
3. In what way(s) does the disease resemble diabetes in humans?
4. For what reason is the insulin treatment not totally successful in prolonging the lives of mice?
5. Is the diabetic gene in mice dominant, recessive or neither? Give reasons for your answer.
6. Show, using conventional gene diagrams how mice with two diabetic genes can arise from a male and female each having only one gene for diabetes.

RESEARCH QUESTIONS

7. There is an error in science in lines 9 - 10. Show how this is incorrect and rewrite it correctly.
8. What is diabetes? What causes it? How is it treated? What are the consequences of diabetes to a sufferer?
9. What is an ovary-transplantation? Why is it done in the case of mice?
10. Why are these experiments being carried out? Is it cruel to use laboratory animals for such experiments? Is it justified?
11. Where are the Islets of Langerhans? Who was Langerhans?

DISEASES CONNECTED WITH BLOOD

Modern man has overcome many diseases that killed earlier man. Such diseases as diphtheria are a thing of the past. But modern man is now faced with other diseases which are just as deadly. Many of these modern diseases are connected with the heart and blood circulation. In fact, heart disease is the most common cause of death in Western countries, such as Australia and the United States.

The most common of these new disorders are high blood pressure, hardening of the arteries, and heart attacks. These disorders are caused by such things as over-work and stress, lack of exercise, over-eating and poor diet. All these things are each person's responsibility and are completely in your hands as an individual, because you decide what food and exercise you take.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   overcome (line 1), deadly (line 3), circulation (line 4), Western (line 5), disorders (line 7), lack (line 9), individual (line 11).
2. Name a disease which is now hardly known at all.
3. Which is the most common cause of death in Western countries?
4. Name another Western country other than Australia.
5. Name two disorders which can cause heart disease.
6. Name two causes of these disorders.

RESEARCH QUESTIONS

7. What can you do to prevent heart disease for yourself?
8. How many people die of heart disease in Australia each year?

THE SENSES AND THEIR LIMITS

As we have seen, our senses can be fooled in optical illusions. This means that we cannot always rely on our senses and that sometimes we need to make measurements using measuring instruments such as rulers.

Not only that, but our senses do have limitations. That is, they have lower and upper limits. For example, the approximate range of hearing of the human ear is from 20 hertz to 20 000 hertz (hertz is a unit meaning cycles per second). Outside these boundaries, we are unable to hear.

However, our senses are a very great help, and we find no problem in sorting out perfume from vinegar. Actually, smells or odours are simply mixtures of four basic odours i.e. fragrant, acid, rancid (cheesy), and burnt. Similarly, tastes are combinations of four basic tastes i.e. sweet, sour, salt, and bitter. These tastes are sensed by "taste buds" on our tongue, with the taste buds being clumped together in a pattern on the tongue.

Finally, we should meet another sense, the kinaesthetic sense. This sense tells us where the parts of our body are and involves balance. Receptors in our muscles join with our sight and the semicircular canals in our ears to inform the brain of the location of the body.

In all these ways, the brain is constantly being informed about our environment. It is not surprising to know that other living things also respond to stimuli. For instance, plants will respond to light and water, and even invertebrates will respond to light or touch.

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1. What do these words mean as they are used in the passage?

   instruments (line 3), limitations (line 4), approximate (line 5), odours (line 9), combinations (line 11), clumped (line 13), location (line 17), respond (line 20), invertebrates (line 21).

2. What information does the brain receive from different receptors?

3. What does the kinaesthetic sense (line 14) tell us?

4. How many "basic odours" are there?

5. What are the "basic tastes"?

RESEARCH QUESTIONS

6. Who was Hertz? Why was the hertz named after him?

7. How does the range of human hearing vary as you get older?

8. Which parts of the tongue can taste
   (i) sweetness,
   (ii) sourness,
   (iii) saltiness, and
   (iv) bitterness?

"CO-ORDINATION - PUTTING IT ALL TOGETHER" 100

Our bodies are organised or co-ordinated by two connected systems. The two systems are called:-

(i) the "nervous system" and
(ii) the "hormonal system",

and are linked together by the brain.

The nervous system is the normal system of senses. In this, a stimulus (for example, a noise) is detected by the receptor or sense organ (in this case, the ear). The noise is turned into a nervous impulse or electrical message which travels to the brain along the auditory nerve. A similar system works for all the other senses, with the brain continually being informed about the outside world. It is the brain, too, that controls our muscles or effectors, causing them to move by electrical impulses. This nervous system is a conscious one.

The hormonal system is less obvious and is in fact not a conscious system. That is, we do not have to think about it for it to work. The brain controls the parts of our body called "glands", and under the control of the brain these glands can give out (or secrete) certain chemicals. These chemicals (or "hormones") are carried around the body by the blood stream to where they are needed. For example, the pituitary gland gives out hormones to cause the start of puberty or adolescence.

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1. Find and write down a word underlined which means the same as the following:
(a) muscles, (b) organised, (c) sense organ, (d) give out, (e) chemicals from glands, (f) able to be thought about, (g) adolescence.

2. Which system works fastest, the nervous system or the hormonal system?

3. What part of our body controls these systems?

MACHINE MEASURES MOSQUITO REPELLENTS

101

Scientists in Vancouver have developed an unusual machine. This machine functions as an 'artificial host' which attracts mosquitoes. This eliminates the need for volunteers, to test the effectiveness of mosquito repellents. Previously these volunteers had to put the repellent being tested on their arms and then expose their arms to swarms of mosquitoes.

The new machine not only saves the volunteers this discomfort. It is also more accurate. Unlike human response, the machine can measure the *exact* amount of chemical repellent vapour needed to cancel out the attraction.

The best repellents are effective at concentrations as low as one part in a thousand million parts of air. This shows that insects are more sensitive than the most delicate instruments now in use.

It is hoped that the information gained through the new 'artificial host' machine will help scientists understand the chemical basis of the repellent effect. This might lead to repellent sprays and creams that are non-greasy and pleasant to use. Eventually it might even lead to a systemic repellent. This could be a 'pill' that would make the user mosquito proof for hours or even days.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?
   functions (line 2), eliminates (line 3), repellents (line 4), response (line 8), systemic (line 18).

2. What is the purpose of the new machine?

3. What are the advantages of the new machine over human volunteers?

4. What do you understand by the concept of an "artificial host" (line 2)?

RESEARCH QUESTIONS

5. Find out why mosquitoes (or other insects) are so sensitive to very small amounts of chemicals.

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BATS STILL USE THEIR EYES

102

In at least two species of bat *Carollia perspicillata* and *Phyllostomus hastatus* vision plays an important part in the avoidance of obstacles. Experiments were carried out on these bats in outdoor cages in Trinidad. The animals had to fly the length of the cages (4.9 metres) passing between vertical strips of white cloth. The 300mm. wide cloth strips were hung across the middle of the cage, with gaps between them 70 - 100mm wider than the bats' wing-span. All the experiments were carried out in subdued daylight.

After about 50 such flights, the bats were then blindfolded (with aluminium or black polythene masks) or deafened (temporarily with cotton wool plugs) or both. They were then allowed to fly through the obstacles again.

The normal bats were well able to avoid the obstacles. Blindfolding these bats had little effect on this ability, whereas deafening them impaired their performance considerably. However, bats which were deafened and blindfolded were much less able to avoid the obstacles. The deafened bats showed no changes in their avoidance noises as they approached the cloth strips. The normal and just blindfolded ones, however, increased their pulse repetition rate when approaching the barrier.

The bats could thus see the cloth and could, to a large extent, avoid the strips using sight alone. While the acute sense of hearing used in echo-location is still the most important factor in the avoidance of obstacles by bats, this passive visual surveillance system is a useful second line of defence. This is especially so in species which rest during the day and are exposed to predators. Also, as acoustic orientation is effective over only small distances, echo location would not detect a distant navigational cue or obstacle even if it was as large as a mountain.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   subdued (line 8), impaired (line 13), acute (line 20) factor (line 21), passive (line 22), surveillance (line 22), predators (line 24), acoustic (line 24).

2. Explain the meaning of the phrases:

   (a) avoidance noises (line 16)
   (b) pulse repetition rate (line 18)
   (c) passive visual surveillance system (line 22)

3. What was the purpose of the experiments described in the article?

4. List the experimental factors (i.e. the different conditions under which the bats flew) used in the experiment. Could any of these group of bats be considered a *control* group? Which one?

5. List in *decreasing* order of ability to avoid obstacles, the various groups of bats used in the experiment.

6. From these results write a conclusion which summarises the observations.

RESEARCH QUESTIONS

7. There are other ways by which animals navigate. See if you can find four other methods and mention the animal(s) which use the methods.

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INSECT BRAINS

103a

Why do we say "as mad as a hornet" or "as busy as an ant"? It is because these creatures, like other insects, are stimulus bound. They do not examine the whole environment and then "decide" what to do by computing a large number of facts together. They simply respond to a stimulus.

The brain of a blowfly has a mass of 0.84 milligrams and contains about 100 000 cells. It is just under 1 600 microns across (one micron is 10^{-6} metre). Thus it is enormous compared with the brain of a midge, which may be only 200 microns across. The smallest brain of all is probably that of the African ant *Oligomyrmax* which is 150 microns across and contains about 1 000 cells. The EEG from such brains is quite unlike that of vertebrates. No one knows if they sleep or even whether they feel pain. They pay no heed to surgery, but dislike electric shocks and insect repellents. How do such tiny brains work?

The blowfly, for instance, searches for sugar with its chemoreceptors quite regardless of the state of its metabolism. In other words, it does not ask whether it is hungry. As soon as it spots sugar, it wolfs it.

The insect brain achieves remarkable results with very few cells, because it sacrifices detail to speed. The phalenid moths, which are hunted by bats with their sound ranging equipment, evade their pursuers quite well with the aid of only two receptors which discriminate intensity but ignore pitch. A moth pursued by a bat goes into a spiral manoeuvre, in no particular direction. It is more urgent to get out of the bat's path quickly than to hang around wondering which way is best to go.

Even more odd, insects are to a considerable extent segmented not only in their soft tissues but also in their nervous system, so that their bodies can act without their heads. A decapitated fly will clean a piece of dust from its leg or wing while the head will continue to feed for a while. In some insects the isolated abdomen is capable of laying eggs. This is fortunate in such insects as the praying mantis where the female bites the head off the male during courtship. This removes the central inhibition and the male is able to co-operate actively during copulation.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? stimulus (line 2), vertebrates (line 12), metabolism (line 16), discriminate (line 21), intensity (line 21), pitch (line 22), segmented (line 25), decapitated (line 27), copulation (line 32).

2. What do the following phrases mean as used in this article? are stimulus bound (line 2), it wolfs it (line 17), achieves remarkable results (line 18), sacrifices detail to speed (line 19), a spiral manoeuvre (line 22), to a considerable extent (line 25), the central inhibition (lines 31 and 32).

3. Why is the word *decide* (line 3) placed in inverted commas?

4. What enables an insect to achieve remarkable results (line 18) with such a small brain? Explain why.

5. Explain the meaning of the term chemoreceptor (line 15). Find out 4 other ways in which insects sense their environment.

6. The passage suggests that a segmented nervous system is important to the praying mantis' way of reproduction. Explain.

7. Examine the tone (style of writing) of this article. To what kind of people do you think the author is writing?

8. What is an EEG (line 11)? What does it do? What is it used for?

9. (a) How many microns are there in a centimetre?
   (b) What is the size, in millimetres of the brain, of the African ant *Oligomyrmax*?

10. Using the information in the first sentence of the second paragraph, calculate the approximate mass of one brain cell of a blowfly.

11. Compare the number of cells in the brain of the blowfly and the African ant. Now compare the widths of these two brains. Explain why these are different.

12. Use the library to find the mass of a human brain. How many times heavier is the human brain than that of a blowfly?

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CHEMICAL MESSAGES BETWEEN INSECTS AND OTHER ANIMALS

104

The vocabulary of chemical signals used by insects and other animals to protect themselves is extensive. There is a vast range of chemicals produced that serve for messages. A whip scorpion discharges an acid spray when disturbed. A millipede secretes a poison from its segmentally arranged glands. An arctiid moth emits froth from its cervical glands. These chemical defences of small animals compare with the rather forceful message written in the stench of a skunk's spray.

The chemical secretion, often of very strong odour and discharged in substantial amounts, is stored in glands. As these glands are so variable in number, distribution and structure, there can be no doubt that they have developed independently in the course of evolution. Such animals as millipedes secrete chemicals by oozing them over their body surface. But perhaps the most spectacular insects are those such as cockroaches and earwigs that spray their chemicals, sometimes for several metres.

Most of the chemicals that have been identified belong to a number of common classes such as the acids, aldehydes, ketones, esters, hydrocarbons and phenols. These substances can be accurately aimed at sensitive areas of the face and so irritate predators that they cease the attack and begin vigorous cleansing activities. Mice wipe their eyes and snouts with their front feet; birds ruffle their plumage and rub their heads against the feathers of their bodies; frogs and toads, which are sensitive over their entire body surfaces, scratch affected regions with their feet.

Sometimes these secretions serve another purpose, such as sending out alarms of approaching danger to members of the same species. The ant *Acanthamyops claviger* produces a secretion that serves both for defence and as an alarm signal. Another set of important substances, of course, is produced by animals to exchange messages of courtship and other social activities. These interesting compounds, called *pheromones*, include sex attractants and territorial and trail markers.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? vocabulary (line 1), discharges (line 3), segmentally (line 5), glands (line 5), secretion (line 8), spectacular (line 13), predators (line 19), pheromones (line 30).

2. For what reason(s) do insects use chemical signals?

3. How do these chemical defences actually work?

4. Why do scientists believe that different animal species have developed chemical defence mechanisms independently rather than their being a result of a common ancestor?

5. What do the chemicals mentioned in lines 17 and 18 (acids, aldehydes, ketones, esters, hydrocarbons and phenols) have in common?

RESEARCH QUESTION

6. Animals use chemical messages for various reasons such as sex attractants, territorial marks, or trail markers. Name one example of each use (total, three animals). For each of your three examples, describe in detail how the animal uses the chemical.

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BEES 'TAILOR-MADE' FOR POLLINATION

105

Honeybees carry out more than 80% of all pollination done by insects. This means that their pollen preferences are most important. Until recently they would generally avoid lucerne if other food was available. This was because the pollen in lucerne is hard to reach. Yet lucerne crops must be grown, because they yield hay and silage. Dr. Otto Mackensen was aware of this problem. He wondered if he could breed honeybees that would prefer lucerne to other crops.

He knew that certain inherited genes controlled the bees' crop preference. After selectively breeding through five generations of honeybees, Mackensen achieved his aim. To test his honeybees he first chose a place with limited pollen sources other than lucerne. Here, 99% of the bees bred to favour lucerne chose this pollen source. He then took the honeybees to a second location. Here there was a much greater variety of pollen sources. Of the specially bred bees, 54% still chose the lucerne.

Mackensen reported that he might now try to breed honeybees who favoured other particular plants. The pear blossom is another 'problem' plant. Bees will not usually pollinate it if other pollens are available because it has a musty odour. If he succeeds he will have produced a second 'tailor-made' bee.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in the article?

   pollination (line 1), pollen (line 2), silage (line 5), genes (line 8).

2. Why did bees tend to avoid lucerne if other food was available?

3. Why was it desirable to have greater amounts of lucerne pollinated?

4. How did Dr. Mackensen determine whether or not his breeding experiments had been successful?

RESEARCH QUESTIONS

5. What is meant by the phrase selective breeding (line 9)? Explain exactly why this process is used and how it is carried out. What is the origin of the phrase?

6. What does the passage mean by the phrase 'tailor-made' bees?

7. Cite at least 2 other examples of selective breeding. State the purpose of each program. What 'starting parents' were used? Why?

8. What is another name for lucerne? what countries use this other name?

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LINK BETWEEN ANTS AND THEIR 'CROPS'

106a

A type of tropical ant whose diet is a fungus that they 'cultivate' themselves is being studied by Dr. Michael M. Martin at the University of Michigan. The fungus cannot survive without the attention of the ants. Martin hopes to find the chemical basis for this association, which is the key to the ants' successful exploitation of their environment.

The ants, called *attines*, inhabit an area extending from Argentina to the southern United States. Each colony serves one queen through a division of labour which is possibly more elaborate than that of bees.

Soldier ants guard the nest while workers of various sizes sometimes cut pieces of leaves from trees hundreds of metres from the nest. The workers carry the pieces back to the nest, where gardener ants cut the leaves even smaller and plant a fungus growth on them.

The ants fertilize the fungus by secreting chemicals on it and remove weeds and other undesirable material from the leaves. Because leaves contain indigestible cellulose, the ants cannot eat them. However, the fungus is effective in decomposing cellulose and converting it into a rich source of nutritive carbohydrates for the ants. By culturing and feeding on such a fungus, the ants have succeeded in utilizing the vast reserves of cellulose material in their environment as a nutrient. Although many insects feed on fungi (fungi grow in the nests of certain beetles and termites), the fungus culturing of the *attines* is believed to be unique.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? cultivate (line 1), association (line 5), elaborate (line 9), fertilize (line 14), secreting (line 14), indigestible (line 16), cellulose (line 17), carbohydrates (line 18), culturing (line 18), utilizing (line 19).

2. What do these phrases mean as they are used in the article?
successful exploitation (line 5),
division of labour (line 9),
believed to be unique (lines 22 and 23).

3. List the different types of ants which inhabit each colony. Against each type, write the 'job' each does.

4. To what purpose do the ants cultivate the fungus?

5. Why do the ants collect leaves from trees?

6. In the passage, it is stated that the fungus cannot survive without the attention of the ants. What is the role of the ants in keeping the fungus alive?

7. Could the ants survive without the fungus? Explain your answer.

8. What does nutritive (line 18) mean? This word is an adjective. What are some noun and verb forms of this word? What does each one mean?

9. a) What is the difference between a *parasitic* and a *symbiotic* relationship.
   b) How would you describe the relationship between the ants and the fungus.

10. Why is cellulose an indigestible substance, not only to ants, but to most other animals as well?

11. Use the library or other resource materials and trace the life cycle of an ant, or a termite. Draw a diagram to summarize your findings and write a page of notes on the life of the insect you have chosen.

★★

BACTERIA

107

Bacteria are very small living things which can be seen only under a powerful microscope. They were first discovered in about 1680 by Anthony van Leeuwenhoek a Dutch draper. His hobby was making small but strong lenses and using them to look at all sorts of things. Some of his lenses were no larger than a tomato pip, but they magnified objects some 200 times.

Leeuwenhoek discovered a whole new world of tiny organisms, many being very important in our lives. Some are useful and some do us harm.

They are in some ways like fungi, in other ways they resemble algae. They are also similar in some ways to one-celled animals. They are found in the soil in the air, and in the depths of the oceans. Bacteria cause food to go bad and dead plants and animals to decay. Many diseases of animals and men are caused by bacteria, and so are some diseases in plants.

All bacteria are very small, and consist of one cell only. If you put 4 000 of them side by side they would measure about 1 centimetre, but even then you might not see them, as most bacteria are colourless. They are usually shaped like balls, rods or corkscrews. Sometimes they are linked in a chain, sometimes like a bunch of grapes. Some are quite still, others have little hairs which help them to move around.

Bacteria increase in number just by splitting in two, and if everything is right for them they increase very rapidly. One bacterium may turn into billions in the space of a day and a night. Luckily nature has several ways of keeping their numbers down, otherwise they would soon cover the entire earth.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? draper (line 3), pip (line 5), magnified (line 5), fungi (line 8), algae (line 8), decay (line 11).

2. List the features common to all bacteria.

3. Where do bacteria live?

4. What do bacteria do? What would the world be like without them?

5. What is the size, in centimetres, of one bacterium?

RESEARCH QUESTIONS

6. Describe in detail using a diagram, one of van Leeuwenhoek's microscopes.

7. List 5 ways in which bacteria are
   a) useful to man.
   b) harmful to man.

8. In what way(s) do bacteria resemble
   a) fungi.
   b) algae.
   c) animals.

9. Draw a series of diagrams to show what
   a) individual bacteria look like.
   b) colonies of bacteria look like.

10. How do bacteria multiply? Use reference books to describe this process in more detail.

11. What is meant by the phrase everything is right for them (line 20). What do bacteria require for everything to be right for them?

★★

EARTHWORM'S MOVEMENT SPEEDS 108

Changes in earthworm's speed of movement are interesting. They move approximately 25% faster in the night than in the day. Their rate of movement is also connected to an annual seasonal cycle. The exact difference between the evening and the midday speeds vary from month to month. This difference is greater in August (46.6%) and least in January (17.6%).

Observations showed that there is also a third factor seeming to influence speed. This is a connection with lunar cycles. The worm seems to react more to a full moon than to a new moon.

One suggestion for this variation is that some or all of these cycles occur in response to geophysical stimuli. These stimuli might be quite obvious to the earthworm, but not apparent to humans.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words means as used in the article?

   annual (line 3), cycle (line 3), factor (line 7), response (line 11), geophysical (line 11), stimuli (line 11)

2. When would an earthworm move fastest?

   A. A hot August day following a full moon.
   B. A cool August night with a full moon,
   C. A January night with a full moon.
   D. A January day following a new moon.

3. What are the three factors which seem to influence earthworm movement?

RESEARCH QUESTIONS

4. What are geophysical stimuli (line 1). Suggest some stimuli which are geophysical.

5. Using the information in the passage, from what part of the world do you think this research comes? Why?

★★

BARNACLES

The barnacle is a small shellfish which belongs to the group of animals called crustaceans. It has a habit of sticking itself to anything convenient. The famous scientist T.H. Huxley described the barnacle as *"a crustacean fixed by its head and kicking its food into its mouth with its legs."* At low tide you can often see a thick crust made up of millions of barnacles on piers, rocks and breakwaters. They fix themselves on to the bottom of ships too. These have to be scraped from time to time to get rid of them.

In the days of small sailing ships, barnacles were a real danger because they slowed down ships and made steering difficult. Many a whaler could hardly get home after a two year cruise, because of the masses of barnacles clinging to its hull.

There are many different kinds of barnacles. One is the acorn. This prefers to live on a rock rather than on wood or iron. It grows on rocks and does not have the short stem that other kinds have. The goose barnacle was given its name because years ago people used to think that it produced goslings. (One of the black and white geese is called a barnacle goose still.) It chooses floating wood or ships and attaches itself with a long stalk.

When barnacles hatch from their eggs, they look like tiny crabs or lobsters and they can swim about. It is only when they grow older that they find some object to cling to for the rest of their lives. Then they grow a shell and only their six pairs of feathery appendages still move about to reach for their food. Their main diet is usually smaller water creatures.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? shellfish (line 1), crustacean (line 2), whaler (line 11), gosling (line 17), appendages (line 23).
2. What are the differences between an acorn barnacle and a goose barnacle?
3. What sort of barnacle would have attached itself to the bottom of whalers?
4. What do the legs of a barnacle do?

RESEARCH QUESTION

5. How does a barnacle attach itself to rocks, or wood or metal?
6. What is an operculum? What is its function?
7. If barnacles are fixed in one spot for all their adult lives, how do they mate?
8. What do barnacles have in common with other crustaceans?
9. Collect some information about "goose barnacles" and "barnacle geese". The best source for this information would be a book called a bestiary. What other strange animals were "believed in" in the Middle Ages?

SOURCE: Adapted from Simon Dresner : "Coral", Science World, Vol. 17, No. 12, Dec. 6, 1968 pages 12,13.

★★

CORAL

110

When Europeans first explored the South Pacific, they were fascinated by the many coral-fringed islands they found. But the explorers did not realise that these islands are really like the tip of an iceberg - an iceberg made of coral.

It's hard to believe that these masses of stone were built up by tiny blobs of jelly, each no larger than a grain of rice. The animal responsible is called a polyp, and belongs to the same family group as the jellyfish and sea anemone.

The coral polyp is a simple creature - it's merely a tube, closed at one end and with a mouth at the other end. The mouth is surrounded by slender tentacles. The tentacles push food into the mouth; waste products are squirted out the same opening.

The polyps feed upon plankton - a mixture of tiny plants and animals, many of them microscopic, that thrive by the billions in seawater. The coral polyps are carnivorous, choosing only animals such as baby shrimp, young starfish, or crabs.

Skeletal material is continually excreted by the base of the polyp, pushing the polyp upward so that it stays on top of its skeleton. The coral polyp produces carbon dioxide, as do all living animals. This combines with calcium hydroxide that exists in seawater formed from the weathering of limestone rocks on land and under the ocean. Calcium carbonate is formed.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What are the meanings of the following words as they are used in the passage?

   tentacles (line 11), plankton (line 13), carnivorous (line 15).

2. What does the author mean when he says that "these islands are really like the tip of an iceberg" (line 3)?

3. How large is a coral polyp (line 7)?

4. Corals belong to the Animal Phylum : Coelenterates. Name two other animals belonging to this phylum.

5. Why do corals make a skeleton (line 18)?

6. What is the skeletal material composed of (line 17)?

RESEARCH QUESTIONS

7. Find out how members of the Coelenterate phylum kill their prey.

8. Name other sea creatures which use plankton as their food.

9. Write chemical formulae for the chemical compounds mentioned in the passage.

10. Write a chemical equation for the formation of calcium carbonate from carbon dioxide and calcium hydroxide.

★★

RECOLONISATION - HOW SUCCESSFUL? 111

What would happen if all small animals and insects in an area were killed? Would they somehow be able to recolonise that area? Two zoologists decided to find out. They selected 6 small, well-spaced islands. Next they placed huge nylon tents over the entire surface of each island. They then sprayed enough methyl bromide under each tent to kill all small animals and insects. The spray did not harm the mangrove trees.

Before fumigation about 28 species of small life lived on each island. Three hundred days after fumigation a check was made. All of the original 28 species had recolonised. However the composition of the various species was much changed. The extinction rate was very high. About every 10 days another species would become extinct.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?
   recolonise (line 2), zoologist (line 2), fumigation (line 7), composition (line 9), species (line 9), extinct (line 11).

2. What was the purpose of this experiment?

3. How was the animal life on the islands killed?

4. Where did the new individuals for the recolonisation come from?

5. Consider this section of the passage - "all of the original 28 species had recolonised. However the composition of the various species was much changed."
   Explain how the species can "all recolonise" if the "composition of the species was much changed"?

"BONE AND SKELETON"

The skeleton of the body has at least three functions. The skeleton supports the body, helping to keep its shape; parts of the skeleton help to protect vital organs, such as the ribs protecting the lungs and the heart, and the bones allow muscles to operate for movement.

Bone itself is a complicated thing. It is made of both living and non-living material. The living material called bone marrow allows bone to grow and repair itself, while the non-living material gives it strength. Another interesting fact is that the red cells in blood are also produced in the bone marrow.

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1. What do these words mean as they are used in the passage? supports (line 2), vital (line 3), operate (line 4), material (line 6), produced (line 8).
2. Which part of the skeleton protects the heart and lungs?
3. Is bone made only of living material?
4. What is the living material in bone called?
5. Can bones heal?
6. Where are red cells made?

RESEARCH QUESTIONS

7. Draw a human skeleton and mark in the names of as many bones as possible.
8. About 1900, "whalebones" were used for many things. Find out what the "whalebones" were, and what they were used for.

SOURCE: The Australian Museum Leaflet No. 58, June 1967.

THE CRESTED WEEDFISH

113a

The Crested Weedfish resembles, in form and colouring a piece of the kelp amongst which it lives. There are often light flecks on the body or window-like transparent spots on the fin-membranes, simulating holes and tears in the weed. The fish is therefore camouflaged so that it is hidden from its enemies (other fishes which eat it) and can approach its prey without being seen. It is a weak swimmer and "walks" along on its finger-like ventral fins, aided by the side (or pectoral) fins, as it stalks the crustaceans, worms and small fishes on which it feeds. It is sometimes hooked on a bait of conjevoi, prawn or fish.

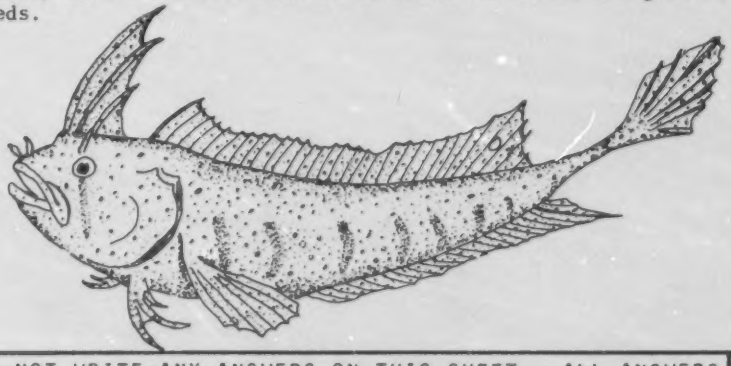
There are several Australian species of Crested Weedfishes in the genera *Cristiceps*, *Petraites* and *Clinus*. They belong to one of the Blenny families (family Clinidae), and are known as Klipfishes in South Africa, where some grow to nearly 0.6 metres in length, and are good eating.

In *Cristiceps* the front dorsal fin forms a crest of three spines on top of the head. In Victoria this fish is known as the "Policeman".

Most of the Australian Crested Weedfishes are only a few centimetres long, but a few reach 15 cm or more. *C. australis* attains 23 cm, *C. aurantiacus* 25 cm and the broad-headed *Petraites johnstoni* 35 cm.

The Crested Weedfish is viviparous. The eggs are fertilized in the female's body and very numerous larval fishes are produced alive. One female *Cristiceps aurantiacus* had about 2170 embryos in her uteri, each one with the tail curled round and the head and eyes resting above the curl of the tail.

The Crested Weedfish's colour is usually brown or greenish, with light and dark markings and often with a dark-brown bar reaching below each eye, but the colouring can be changed to harmonize with the fish's surroundings. They are fishes of the shoreline, found usually in a few metres down to 60 metres of water, among rocks and weeds.



DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean, as used in this article?

   kelp (line 2), simulating (line 4), stalks (line 9), crustaceans (line 9), cunjevoi (line 10), larval (line 24), embryos (line 25), harmonize (line 30).

2. The words genera (line 13) and uteri (line 26) are both plural. What is the singular for these words? What do they mean?

3. (a) In what way is the Crested Weedfish camouflaged?

   (b) Of what benefit is this camouflage to the fish?

4. What is the meaning of the word viviparous (line 23)? How is the crested weedfish different in this regard from most other fishes?

5. What do you think *C.* stands for in *C.australis* (line 21) and *C.aurantiacus* (line 22)?

6. The diagram shows an adult specimen of *Cristiceps aurantiacus*. This diagram is about

   A. one quarter the size of the fish.
   B. half the size of the fish.
   C. the same size as the fish.
   D. twice the size of the fish.

7. Make a neat copy of the diagram. On this diagram label the *ventral fins*, *pectoral fins*, and the *front dorsal fin*.

8. Next to your diagram draw a small scale showing the size of the weedfish.

9. Using information in the article use appropriate coloured pencils to colour in your diagram.

RESEARCH QUESTION

10. Why is the crested weedfish known as "Policeman" in Victoria?

AXOLOTL HEADS TRANSPLANTED ★★★ 114

In the past scientists have experiemented with transplanting the head of a young dog to the body of another living dog. These attempts have failed. Either the head has not functioned on the host dog has died. With axolotls it has been different. The heads of axolotl larvae have been transplanted on to older axolotls. Not only have some of these second heads survived *in situ* but they have also showed signs of movement and function afterwards. This is probably because the axolotl can regenerate many different tissues, even brain tissue.

One experiment involved 49 grafts of heads from larvae 1.6 to 1.7cm long on to older animals of 6 to 8cm. Thirteen of the grafts remained attached to their hosts. The rest dropped off after 2-3 days. Immediately after transplantation the heads became pale. Two days later they reddened, showing circulation was restored. About nine days after the operation the second heads looked normal and began to grow. The growth rate of these second heads was faster than that of the original heads. This implies that separate mechanisms controlled the growth rates of the two heads even though the body supplied the same growth hormones to both heads. In a few cases the transplanted head eventually grew as large as the host head.

One of the female hosts was so little worried by the transplant that she mated and produced offspring. Six of the successful grafts also showed movement. To encourage this movement the heads were stimulated. In response to this they opened their mouths and drew in their eyes. Apart from these simple responses, however, they could do little. When, for example, the host head was feeding, the transplanted head did not move at all.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   regenerate (line 8), grafts (line 9), mechanisms (line 16), hormones (line 18), offspring (line 21), stimulated (line 23), responses (line 24).

2. What is the meaning of *in situ* (line 6)?

3. Why have axolotl transplants been more successful than dog transplants?

4. What evidence do scientists have to suggest that the transplanted heads and the host heads are controlled by separate mechanisms?

5. Redraw and complete the following table:-

Total Number of grafts	Unsuccessful grafts	Showing Responses	Not Showing Responses

RESEARCH QUESTIONS

6. What are axolotl larvae (lines 4 & 5)? Find out more about the life cycle of the axolotl. Write a page of notes, including a diagram of the life cycle.

7. Regeneration (line 8), is a process which quite a few animals can carry out. Find out
   a) in general, what sort of animals can regenerate in the way suggested in the passage.
   b) five other animals which can regenerate like axolotls.

8. There have been in Australia, at least two disastrous ecological situations arising because of the regenerative abilities of animals. Find out more about these (Hint: Great Barrier Reef, oyster farming in Newcastle).

9. Why would scientists want to conduct such bizarre experiments as these? Are they justified? Are they cruel?

10. Who was Pavlov? What relevance does this scientist have to this article. Discuss some of his work.

★★

ODE TO THE CAMEL

115

The fat in the hump of a camel is not metabolically wet,
For the water it loses respiring is greater than it could thus get.
The wool(or fur) of these beasties protect their innards from heat;
The eyes are soon hidden from sandstorms - and consider the size of
    their feet.
It's truly an interesting mammal; its temperature soars in the sun
To full forty degrees before sweating - I doubt if that's very much fun.
The kidney of all dromedaries can concentrate urine and salt;
They can lose over a third of their fluid before they are brought to a halt.
But the rate which they swallow down water, if water they happen to find,
Is up to twelve litres a minute, which leaves us a long way behind.
When staying alive without water, the camel is certainly boss.
They don't have to drink water in winter, enough is dry fodder and dates,
So why call them the *'ships of the desert'*, those odd, even-toed ungulates?

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this poem?
   metabolically (line 1), respiring (line 2), innards (line 3), dromedaries (line 8), concentrate (line 8), fodder (line 13), ungulates (line 14).

2. Why do you think camels are called the *ships of the desert* (line 14)?

3. What does the poet mean by the first two lines of this poem?

4. What one characteristic of mammals mentioned in this poem leads you to the conclusion that the camel is a mammal?

5. List *four* characteristics of camels mentioned in the poem which suggest that camels are well suited to the environment in which they live?

6. There *seems* to be a contradiction in the expression "odd, even-toed ungulates" (line 14). Explain this *apparent* contradiction.

RESEARCH QUESTIONS

7. The camel mentioned in this poem is the dromedary. There is another type of camel known as the Bactrian camel. What are the differences between these two types?

8. It has been said that there are more camels in Australia than in Africa. How did this come about?

★★

SEEDS GERMINATE AFTER 500 YEARS

116a

Germination of seeds estimated to be 500 years old has taken place. Scientists were given the seeds by archaeologists. The seeds were part of a necklace made of *Juglans australis* nuts. The necklace came from an ancient tomb which has just been excavated. Inside each of the nuts was a seed of *Canna*. Carbon-14 analysis of some animal bones also found at the excavation site dates the seeds at around A.D.1420.

To see if the seeds would germinate, scientists placed one seed on moist filter paper. This was placed inside a Petri dish covered with polyethylene. The glass was kept in the dark at a temperature of 27°C. After a few days a rhizome appeared and grew to about 2mm long. Growth then ceased. Fertilizers were added but had no effect.

A second *Canna* seed was sown in sterile conditions in a highly nutritious medium. Two fresh control seeds were also placed in this medium. The darkness and 27°C temperature control were again set up. After 3 days scientists found that all three seeds had germinated. Rhizomes sprouted first, then roots and finally, leaves appeared. The plants were gradually exposed to light to permit photosynthesis and were then transferred to an environment of 21°C.

By the tenth day the ancient seed had a leaf which measured 3·3cm but which was still tubular. It had a good root system. The only apparent abnormality was some disturbance in its geotropism. The second control plant at this time had a 1.5cm leaf. The plants were later planted in gravel and kept in a greenhouse where they continued to grow and develop. Although the leaves of the ancient plant and the control plant differed this may not be due to the age factor. It may have been caused by a difference in the variety of the old and new seeds.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article? germination (line 1), archaeologists (line 2), sterile (line 14), nutritious (line 15), photosynthesis (line 20), tubular (line 23), abnormality (line 24).

2. a) What is control (line 15)?
   b) Why is a control used in an experiment?
   c) What control(s) are used in these experiments?

3. Draw neat, well-labelled diagrams to show how the ancient seeds were 'set up' in the experiment described in paragraph 3.

4. After successful germination and growth occurred, several differences were noticed between the ancient seed plant and the control seed plant. List these differences. Why did they occur?

5. What is rhizome (line 18)? What is its function? Where would you expect to find it? Draw a diagram to show what a rhizome looks like.

6. Why were the seeds placed in the dark (paragraph 2)? Do plants need light to grow?

RESEARCH QUESTIONS

7. What is geotropism (line 25)? Design an experiment which attempts to show that geotropism does occur.

8. How does Carbon-14 analysis work (line 6)? How do scientists use C_{14} analysis to determine the age of a specimen? How accurately can scientists measure age this way? Explain your answer.

9. How can the dating of animal bones by C_{14} methods give the age of a plant seed?

★★

CARNIVOROUS PLANTS 117

All animals depend on plants for food. Herbivores depend on plants directly. Carnivores, by preying on herbivores, depend on plants indirectly. However, this dependence is occasionally reversed.

In all, there are about 450 species of carnivorous plants. These depend on animals for their primary source of protein. Some fungi are also carnivorous. Plants usually prey on insects, but some "eat" small birds and mice. Fungi tend to prey on microscopic animals like the eelworms. No known plant preys on larger animals. However, there are stories of a man-eating plant in Africa. However, no scientific evidence of its existence has been found.

It is not known why plants obtain their nutriment this way. However, it is significant that many live in marshy ground. This tends to be very acidic in nature and lacks ammonium salts and nitrates. It is these chemicals that plants usually use a source of nitrogen. It is thought that carnivorous plants also obtain potassium and phosphorus from their animal prey.

The evolution of these plants is almost completely unknown. A species of *Utricularia*, the bladderwort, has been found in Tertiary rocks, but little else has been found as fossils.

It is a mystery how their complex organs of capture evolved. Many biologists suggest they arose by accident and that the benefit of having them gave a selective advantage to the plants having them.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? herbivores (line 1), carnivores (line 2), dependence (line 3), primary (line 5), prey (line 6), nutriment (line 11), complex (line 19), evolved (line 19), arose (line 20).

2. Why do carnivorous plants "eat" animals?

3. What is scientific evidence (line 9)? Why do scientists like to have scientific evidence to support their findings?

4. Why is the evolution of the plants almost completely unknown?

RESEARCH QUESTIONS

5. Find out the names of five different carnivorous plants. Draw and describe one of these.

6. Australia has many carnivorous plants. Why?

7. The last paragraph of the article seems to imply inheritance of accidentally acquired characteristics. Does this suggestion have a place in theories of genetics or evolution? Explain why.

8. What is meant by the phrase selective advantage (line 21). What is the origin of this term?

SOURCE: Life Science Library - The Scientist ★★★

EARTH SCIENCES 118

Earth Science is a relatively new area of study. Most of its branches sprang into existence almost simultaneously at the beginning of the nineteenth century. Such branches include geophysics, stratigraphy, historical geology, palaeontology, geomorphology, petrology and physical geology. Before this specialization, however, several of man's ancient activities had led to some knowledge of the earth. The most fruitful were geodesy (measurements of the earth's size and shape) and mineralogy. Astronomy, cosmology and meteorology also contributed to our knowledge of the earth from early days.

The surge of activity at the close of the eighteenth century was inspired by a raging controversy over the age of the earth. This was fuelled by religious factors. Fossil remains being discovered around the world called into question the Biblical account of ancient history. The fossils indicated that the earth was far older than anyone had thought. Free of old ideas, men began to investigate the earth scientifically for the first time. The earth sciences split and split again. Separate branches to study the oceans, land waters, and the composition of the earth were formed.

Partly because of the late start, knowledge about the earth is still relatively small and controversial. All the data so far collected, for example, cannot explain the earth's origin. Astronomers may still solve this problem before the earth scientists do so.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage. fruitful (line 7), contributed (line 9), fossil (line 12), composition (line 17).

2. What caused the upsurge of interest in Earth Sciences in the early 1800s?

3. Why is our knowledge of the earth so small, (especially when compared with other branches of science)?

4. What event or events most probably stimulated the controversy about the age of the earth?

RESEARCH QUESTIONS

5. What is meant by the phrase "investigate the earth scientifically"?
Explain the difference between scientific and unscientific investigations. List several in each category.

6. Find out what each of the branches of earth science (underlined in lines 3, 4 & 5) study. Find 3 others not mentioned in the passage.

7. Geodesy (line 7), is the study of the earth's size and shape. Write about 1 page on the methods used by ancient earth scientists in the study of geodesy.

8. How could astronomy, cosmology and meteorology (line 8), contribute to the knowledge of the earth in early days? Do they still contribute? If so, how?

★★★

FOSSIL 'GOLDMINE' FOUND IN AUSTRALIA

119a

CANBERRA: Remnants of abundant animal life which roamed the edges of great lakes in a verdant central Australia 26 million years ago have been unearthed by two Commonwealth scientists. Their find: a Tertiary deposit (they nave named the Camfield Beds) near the Roper and Victoria rivers in north central Northern Territory. It has been described by Australian paleontologists as a "goldmine". It consists of light coloured calcareous sandstone, siltstone and limestone. A coarse lime cemented conglomerate at the base contains clasts of duricrust and pre-Tertiary rocks.

The unit unconformably overlies Antrim Plateau Volcanics (early Cambrian) and Montejinni Limestone (early Middle Cambrian) and is estimated to have a total thickness of more than 20 metres. Fossil vertebrate remains are scattered throughout the upper half of the exposed section. Drs. M. Plane and C.G. Gatehouse of the Commonwealth Bureau of Mineral Resources, who discovered the beds, report fossils of fresh water molluscs, remains of predecessors of the lungfish found today in Queensland and teeth from prehistoric relatives of the crocodile. The site has also yielded remains of giant ground birds, heavier and thicker set relatives of the emu and cassowary. The biggest 'nugget' is a collection of marsupial remains including representatives of the *Diprotodon* and *Thylacoleo* families.

Plane and Gatehouse say they have found remains of a larger and more morphologically advanced version of the *Diprotodon* than that found in the Lake Eyre Basin in northern South Australia and believe it to be of the middle to late Miocene. The *Thylacoleo* - marsupial lion about the size of a large dog - remains were at the time of writing being prepared for description.

This new fauna forms a link in the Australian Tertiary vertebrate evolution and, together with the Lake Eyre sequence and Alcoota and Riversleigh (north western Queensland) faunas, provides a basis for correlating mammal bearing Tertiary sediments in central and northern Australia.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article?

   remnants (line 1), verdant (line 2), paleontologists (line 6), calcareous (line 6), unconformably (line 9), predecessors (line 15), cassowary (line 18), nugget (line 18), morphologically (line 21).

2. List the various animals mentioned in the recent fossil find.

3. Fossil remains of a marsupial lion have been found in two places. Name them.

4. What is the geological (or biological) importance of this find?

5. What is the meaning of the term unconformably overlies (line 9)? Explain, with the aid of a diagram what this might look like?

6. The article mentions a "goldmine" (line 6) and a 'nugget' (line 18). Why?

7. Explain the difference in appearance and composition of the four sedimentary rocks mentioned in the article.

8. What is a clast of duricrust (line 8)? Explain how it forms.

9. How old are pre-Tertiary rocks (line 8)? What does the term Tertiary mean? What does it refer to?

10. What is a *Diprotodon*? Draw one and name a present-day animal to which it is related.

★★

CHANGING COASTLINES 120

One of the main factors at work in changing our coastline is wave action. As a wave approaches the coast and breaks, it stirs up sand from the bottom. This happens all the time, but particularly in rough weather.

Most wave action is influenced by the tides. The waves interact with the tidal currents. The tidal currents often run parallel to the coast and cause the waves to move slightly sideways. The direction of the sideways movement depends the direction of the tide. If the tide is coming in, the sand moves one way. If the tide is going out, the sand moves the opposite way: the sand moves back and forth with the changing tide.

However, either the flowing tide or the ebb tide is usually stronger. This results in an overall movement of sand in the direction of the stronger tide.

In this way, a vast amount of sand can be shifted each day. In abnormal weather, a beach may even be completely eroded away overnight.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in this article? factors (line 1), wave (line 1), tides (line 4), currents (line 5), ebb (line 11), vast (line 14), abnormal (line 15).

2. Why do waves often break at an angle, rather than straight on?

3. What is a) a flowing tide (line 11)
   b) an ebb tide (line 11)?

4. Why is there a net *movement* of sand in one direction along the beach?

RESEARCH QUESTIONS

5. How are ocean waves formed?

6. What effect do the sun and the moon have on the world's oceans?

7. Why do beaches build up in summer and erode away in winter?

8. What can man do to stop the shifting of sand
   (a) below the waterline?
   (b) above the waterline i.e. on the beach?

9. Man's activities have caused changes in the coastline. Describe one change that has resulted in erosion of the coastline. How can this be corrected?

SOURCE: Thayer Willis : "Cape Cod" Science World, Vol. 17, No. 1 Sept. 13, 1968, pages 6,7.

★★

CAPE COD

121

Geologists describe four ways that material is worn away or eroded - by the action of streams, waves, glacial ice, and wind. By far the most important in shaping the shoreline of Cape Cod has been erosion by the waves.

As a wave approaches the shore it runs into shallower water. The trough water at the bottom of the wave is slowed down. The wave becomes steeper and its crest falls forward. The wave collapses into a swirling line of foaming water - a breaker. The mass of water from the breaker surges up the sloping foreshore of the beach.

When a storm wave hits the beach, however, it smashes across the foreshore and strikes a blow at the sandy terrace behind it. Each backwash of the wave carries sand grains back into deeper water.

But waves seldom strike the beach squarely. Usually, they approach at a slight angle. When they do, sand is carried not only up and down the foreshore, but also along the beach. This movement of sand along the shore is important in forming the immense sand bars that jut out at each end of the Cape. A similar movement of sand along the coast occurs offshore in deeper water.

Waves direct their strongest attacks at points and headlands that jut out into the sea. Bays and harbours suffer much less from wave action. Thus the once jagged outline of the Cape was slowly pounded into the smooth curve it is today.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are listed in the article?
   eroded (line 1), crest (line 7), breaker (line 8), foreshore (line 9), backwash (line 11), sand bars (line 16), headlands (line 19).
2. Name four methods of erosion.
3. Why does a storm wave reach the sandy terrace behind the foreshore, whereas ordinary waves do not.
4. Explain how wave action can move sand grains along a beach.
5. Why are points and headlands more subject to wave action than bays and harbours?

RESEARCH QUESTIONS

6. Find out why a breaker "breaks".
7. Suggest reasons why waves seldom strike the beach squarely.
8. In many parts of the world, for example, along the N.S.W. coast, points and headlands still exist. Why have these survived while those at Cape Cod have been eroded away?
9. Where is Cape Cod? Draw a map of the area.

SOURCE: Life Science Library - Energy ★★★

VOLCANIC ERUPTIONS 122

Less than 64 km beneath the earth's surface are pockets of dense molten rock and gases called magma. This seethes at temperatures up to 1800°C. This molten mass is caused by tremendous subsurface pressures and heat, created by the energetic decay of radioactive substances. Occasionally this magma finds a fissure in the earth's crust and is forced towards the earth's surface. In some areas hot gases from cooling magma heat underground water to such a point that it spouts up in geysers.

Some vulcanologists point to evidence that in the last few thousand million years volcanoes may have produced all the gases in the atmosphere, all the water in the oceans, and much of the land. Only 500 volcanoes are known to have been active in recorded time, but some of their eruptions have dwarfed nuclear blasts.

When Krakatoa exploded in the Pacific in 1883, a mountain vanished, walls cracked 160 km away, tidal waves killed 36 000 people, and the sound was heard 5 000 km away.

Molten lava bursts from Kilauea Iki lasted for 36 days in 1959. Some of the jets of liquid magma being forced from the earth's depths were sent 500 metres into the air. So much lava poured out, that the remaining pool is expected to take 100 years to cool.

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1. What do these words mean as they are used in this article?

   dense (line 1), magma (line 2), seethes (line 2), mass (line 3), fissure (line 5), molten (line 16).

2. How have the pockets of magma formed?

3. What are volcanoes?

4. What is a geyser (line 7)? Using a diagram, show how a geyser works.

5. Vulcanologists have made up an hypothesis about the formation of the earth's surface. What is it?

RESEARCH QUESTIONS

6. Make a list of three other disastrous volcanic eruptions, showing where and when they occurred, and the damage to life and property they caused.

7. What is a thermal region? Thermal regions are often popular tourist attractions. Draw a landscape diagram of a thermal region and label its thermal features.

8. What is radioactive decay? How does "the energetic decay of radioactive substances" melt rocks?

VOLCANOES AND MANKIND

Man has always been interested in volcanoes. He has seen the might and power of volcanic eruptions and has often seen great loss of life and property because of them. In the early history of man, it was even thought that there were "volcano gods", and many myths and legends grew up around volcanoes. Nowadays, we think of volcanoes as simply lava being forced out of the earth's surface. We think that this lava comes from magma, which is molten rock formed underground.

There are more than 600 active volcanoes in the world, and many thousands which are extinct. The Hawaiian Islands are volcanic and other famous ones include Krakatoa, Etna, and Vesuvius. Australia has no active volcanoes but has had many in the past. Examples of these past volcanoes are the Warrumbungles in N.S.W. and the Glasshouse mountains in Queensland. Many quarries have volcanic rock and there are many dykes along the coast of New South Wales.

It is interesting to find too, that man makes use of volcanoes. He often farms the rich volcanic soils, and uses broken up basalt in the form of "blue metal" on roads. It is also thought that metal ores are igneous in origin, and mineral deposits such as gold, tin and diamonds are produced by igneous activity.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. Explain the meaning of each of the words underlined: eruptions (line 2), molten (line 7), dykes (line 13), basalt (line 15), origin (line 16).
2. What damage can volcanoes cause?
3. What are myths and legends (line 4)?
4. What is lava (line 5)?
5. What is magma (line 6)?
6. How many active volcanoes are there in the world?
7. Name two useful things that man gets because of igneous activity.
8. Does Australia have any active volcanoes?
9. Where are the Warrumbungle Mountains?
10. Name two famous volcanoes.

RESEARCH QUESTIONS

11. Find out the origin of the word dyke (line 13). Is it a good word to use?
12. Where is the nearest extinct volcano to you?
13. Find out what a placer deposit is, and how it is formed.

SOURCE: How and Why wonder book on Our Earth. ★★

HOW WERE MOUNTAINS FORMED

124

If we were able to slice open a mountain range such as the Blue Mountains, the Rockies, the Andes or the Alps, we would see crumpled, bent and broken layers of rocks. We would also find that many of the rock layers that now tower thousands of metres above sea level were once formed at the bottom of the ocean. We know that this happened because the fossil remains of sea animals have been found in rocks on the topmost peaks.

From these facts, we conclude that the mountains were formed from the rocks of ancient sea floors, and that powerful forces from within the earth broke and folded and raised these rocks into their present positions.

When the mountain ranges rose slowly out of the sea in this way, other forces began at once to go to work. Swift-flowing streams and slow-moving glaciers began wearing the mountains away. This process of wearing the land away by the action of moving water, is called erosion. As soon as the mountains rose above the sea, erosion began to destroy them.

Geologists believe that the surface of the earth is constantly changing in this way - that the earth's crust is in constant motion, like the waves on the surface of a sea. But instead of rising up and levelling off again in seconds, as sea waves do, the movement of the "waves" of the earth's surface is measured in terms of hundreds of millions of years.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? fossil (line 6), glaciers (line 13), erosion (line 14), geologists (line 16), crust (line 17), motion (line 17).

2. What two forces in earth are acting on the rocks in mountains?

3. What evidence do geologists have that some rocks in mountains were formed under the oceans?

4. In what way(s) do geologists think the earth's crust is like the sea? In what way(s) does it differ?

5. In the article, an *analogy* has been used. What is an analogy? Find the analogy which has been used in the article?

6. Why has "waves" (line 19) been placed in inverted commas?

RESEARCH QUESTIONS

7. Water is mentioned as an agent of erosion. There are two others: what are they? Briefly tell how each of the 3 agents wears away rocks. What does "agent" mean here?

8. What term does a geologist use to mean "to slice open a mountain range" (line 1)?
How does a geologist use such a "slice".

9. (a) How would you classify the rocks you would see in the "mountain slice"? Give evidence from the passage to support your classification.

(b) What would be the classification of the original rocks - the ones formed under the oceans?

SOURCE: Adapted from "Everything has a history" J.B.S. Haldane, Allen & Unwin (1951)

THE EARTH GOES AROUND THE SUN

125

The moon rises slightly later every day compared with the sun. On average, the moon rises and sets each day nearly an hour later. In the same way, the sun lags about four minutes a day relative to the stars. These things can be explained and accurately calculated by a simple idea.

This idea states that the earth and planets move around the sun. According to Kepler's laws, the path of the earth around the sun is an ellipse. But, it has been found that the orbit is not exactly an ellipse, because the earth is attracted to other planets as well as to the sun. Using this information, we can measure the size of the solar system.

For instance, it is quite easy to find out how far away the moon is from the earth. You can photograph it simultaneously against a background of stars in England and South Africa. You can see at once that it has shifted, as a near object changes its position relative to its background if you look at it first with your right eye and then with your left. It is not easy to find out how far the sun is. Occasionally the planet Venus passes directly between the earth and the sun, and can be seen as a black dot. By comparing the time taken by Venus in transit (as this phenomenon is called), as seen from different parts of the earth, the sun's distance was fairly accurately measured in the eighteenth century.

Another measure, not quite so accurate, is the lag of about 16 minutes in the times at which Jupiter's satellites are seen to be eclipsed when the earth is farthest away, compared with when it is nearest. The important point is that these (and other) methods all tell the same story.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean, as they are used in the passage. lags (line 3), ellipse (line 7), simultaneously (line 11), transit (line 17), phenomenon (line 18), satellites (line 22).

2. What is meant by the expression "the sun lags ... relative to the stars"? (line 3)

3. Haldane is English, and so named England as one of the two places for moon photography.
Why would he use South Africa as the other?

4. By how much does the sun lag in a year? Give your answer in hours. Comment on your results.

RESEARCH QUESTIONS

5. (a) Light travels 300 000 kilometres per second. From the last paragraph, calculate the size of the earth's orbit.
(b) How correct is your answer from part (a)?

6. (a) How many satellites of Jupiter are there?
(b) Who discovered the first four satellites of Jupiter? Did he realise what could be done with them?

7. (a) What is the *transit of Venus*?
(b) In Australian history, the study of one transit of Venus has been very important. Why?

8. What are Kepler's laws? Are they still thought to be true?

9. What does the author mean by the last sentence?

★★

WILL TRITON CRASH?

126a

Triton is the largest of Neptune's moons. It ranks as one of the giant satellites of the Solar System. Like Jupiter's Ganymede and Saturn's Titan, it has about twice the diameter of Earth's Moon. (The Moon itself has about one quarter the diameter of the Earth.)

Triton is about the same distance from Neptune as the Moon is from the Earth (about 400 000 km). It has an unusual "retrograde" orbit around Neptune and tidal friction is causing it to move closer to the planet. (The Moon, on the other hand, orbits in the same direction as the Earth's spin and is gradually moving away from the Earth.)

In the case of Neptune and Triton, tidal effects are much greater than in the Earth-Moon system. This is due to their larger sizes - Neptune is 19 times more massive than the Earth and four times the diameter. Just as on the Earth, a bulge is raised on the surface of Neptune by the gravitational attraction of its moon. However, the planet's surface is spinning in the opposite direction to Triton's orbital motion. As a result, the bulge cannot 'keep up' with Triton and is always somewhat out of line with it. The raised area on Neptune's surface causes a dragging force that contributes to the ever tightening orbit.

If Triton does eventually crash into Neptune, the results are not likely to be as catastrophic as if the Moon crashed into the Earth. Quite likely, Triton will not crash at all, but will break up into pieces when it gets too close to Neptune and end up as a set of rings like those around Saturn.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as used in this article? satellites (line 2), retrograde (line 7), friction (line 8), tidal (line 12), catastrophic (line 23).

2. Write down the names of four planets mentioned in this article. Alongside each write down the name of its moon mentioned in the article.

3. If Triton were actually to crash into Neptune, why would the results be less catastrophic than if the Moon crashed into the Earth? (Hint: compare the masses of the planets and their satellites.)

4. What fraction of the Earth's diameter is Triton's diameter?

5. Sketch the Neptune-Triton system, showing the directions of the planet's spin and the moon's orbital motion. Draw the planet and moon approximately to scale, and show the likely position of the tidal bulge on Neptune's surface.

6. Find out how many moons are presently known to orbit each planet in the Solar System?

7. Find out the names of the four largest 'Galilean' moons of Jupiter. Why are they called the Galilean moons?

8. Are the tidal movements in solid parts of a planet smaller or larger than in the liquid parts of the planet? Give reasons for your answer.

★★

SOURCE: Adapted from J.J. Haggerty : "Man's Conquest of Space", Vistas of Science Vol. 12, N.S.T.A., 1966.

127

RE-ENTRY

While an unmanned satellite can be allowed to burn up in the atmosphere when its usefulness has ended, a manned spacecraft must be brought safely back to earth. To do this special devices are needed.

First the spacecraft must be slowed down. In some capsules, small retrorockets located at one end slow the craft. As the retrorockets slow the capsule, the spacecraft drops earthward. Then comes the critical re-entry. Although the capsule has lost some of its orbital velocity, it is still moving at a terrific rate - 16 000 to 24 000 kilometres an hour. At this speed, contact between the capsule and even very thin air builds up great friction that can destroy the capsule if protection is not provided. This protection is a heat shield, a heavy layer of fibre glass on the bottom of the capsule, which strikes the atmosphere first. Part of the shield is actually melted by the heat of friction and peels off the spacecraft.

After re-entry, the capsule slows more and more from air resistance. It drops to an altitude of about 3 000 metres but is still moving at a few hundred kilometres per hour - much too fast for safe landing. To slow the spacecraft further, a large parachute pops from the top of the capsule. To soften the impact of landing, a large rubber cushion between the heat shield and the cabin inflates like a balloon for a gentle "touch down", or "splash down".

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words or terms as used in the passage?

   satellite (line 1), devices (line 3), retrorocket (line 5), orbital velocity (line 7), heat shield (line 11), melted (line 12).

2. Why must some space capsules be brought safely back to earth while some others are allowed to burn up?

3. How do retrorockets slow the spacecraft?

4. How could friction destroy the spacecraft?

5. Why not use the parachute first instead of the retrorockets?

6. What function does the rubber cushion perform?

7. Which slows the spacecraft down the most?
   a) the retrorockets
   b) the parachute
   c) the rubber cushion
   d) the heat shield.

RESEARCH QUESTIONS

8. Why does the heat shield protect the spacecraft?

9. Find out about each of the following manned space research programs: Mercury, Gemini, Soyuz, Apollo. What were the main achievements of each program? When were the flights made?

10. What was the name and nationality of the first person to orbit the earth in space? When did he do this?

SOURCE: Science Journal

★★★

BETTER RUNWAY ARRESTER USES FOAMED PLASTICS

128

The Royal Aircraft Establishment at Farnborough has developed a new system to bring to rest aircraft overshooting a runway.

The new system, claimed to be superior to those presently in use, has been tested at the RAE's airfield at Bedford.

In this system, the material used is a special urea formaldehyde resin developed by BIP Chemicals of the Turner and Newall Group, who have also patented a method of laying a bed by pouring from a hose.

In the test illustrated some five tonnes of foam were laid in the form of two 15 metre long strips. Into these a 16 000 kg test-vehicle, in the form of the major part of a Phantom fighter, was catapulted at more than 130 km/h. The main wheels of the vehicle pulverised the foam and the mean deceleration was approximately 0.6g. Turner and Newall estimate that a 91 metre bed one metre deep would halt "a fully loaded airliner" travelling at 113 km/h, while 300m would stop one travelling at 240 km/h.

An operational bed would be laid across the whole width of the runway overrun area. Once set, the foam can support heavy rescue vehicles, the compressive strength being some 3.5 kg/cm^2. It is non-inflammable and "can be left for years without maintenance". A particular advantage in comparison to other systems is claimed to be the fact that particles of foam thrown up upon aircraft impact are "so light and soft that they are unlikely to damage the fuselage or engines".

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? resin (line 6), catapulted (line 10), pulverised (line 11) deceleration (line 12), operational (line 15), compressive-strength (line 17), fuselage (line 21).

2. What would be the dimensions (size) of the bed of foam needed to stop a fully laden airliner which was travelling at 240 km/hr?

3. What advantage(s) does the new plastic foam have over other systems of stopping overshooting aircraft?

4. What is the mass in tonnes of the test vehicle (line 9)?

5. What do the letters RAE (line 4) stand for?

RESEARCH QUESTIONS

6. What other substances are used to stop aircraft overshooting runways?

7. What is meant by 0.6g (line 12)? Is this a large amount compared with normal gravity?

8. How do scientists research the effect of 'g' force on the human body. Why is this information required?

9. Mention 5 other situations when humans are likely to experience 'g' forces. How large are these forces likely to be?

10. Explain how the law of conservation of energy is operating in the process of stopping the overshooting aircraft.

★★

SUGAR SUBSTITUTE PROCESS FROM DENMARK

129a

COPENHAGEN: The Danish inventor Karl Kroyer, who already has to his credit a process for making paper without the use of water, a skid resistant and anti-glare road surfacing material, and a method of raising sunken ships by pumping them full of polystyrene balls, has developed what he hopes will become an important substitute for sugar. The product, which Kroyer calls 'total sugar', is not exactly new - and is, in fact, glucose. However, what Kroyer has done is to develop a new and commercially viable process for producing crystallised glucose from starch products. This crystallised glucose looks very much like ordinary white cane or beet sugar - sucrose.

Although the product is only about three quarters as sweet as sucrose, Kroyer is placing his hopes on the dietary benefits of glucose over sucrose. A good deal of research has by now shown that there is a link between sucrose consumption and cholesterol levels and that the cholesterol level can be reduced by substituting glucose for sucrose. Sucrose is also a much better medium for growing bacteria such as the streptococci which produce dental caries; indeed, Swedish experiments with hamsters have suggested that the incidence of caries could be much reduced by a similar substitution.

Kroyer is currently planning a conference, to be held in October, for the food industry to persuade them to change their recipes in favour of glucose. So far there are only two plants producing total sugar, one in Holland and the other at Ashford, Kent, operated by Hovis-McDougall, and their output is only about a tonne an hour. But the prospects are promising, says Kroyer. The cost of producing total sugar is about the same as producing ordinary sugar, but any starch product can be used as raw material for the process.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words or phrases as they are used in the passage?

   commercially viable (line 7), crystallised (line 8), link between (line 12), medium (line 15), caries (line 17), prospects (line 22).

2. What are some of Kroyer's inventions?

3. According to the article, Kroyer suggests that the food industry should change from using X to using Y. Identify X and Y.

4. What is the main production advantage of the Kroyer process?

5. Why does Kroyer want the food industry to start using glucose in the place of sucrose?

6. Why does Kroyer need to persuade the food industry to change from sucrose to glucose - why wouldn't the industry automatically accept his recommendations?

7. What are dietary benefits (line 11) of glucose?

8. Why do you think Kroyer called the product 'total sugar'? (line 5).

RESEARCH QUESTIONS

9. What are the chemical differences between glucose, sucrose and starch?
Mention physical, chemical and structural differences.

10. What is the difference between sugar and sucrose?

11. Write a brief summary of the commercial method of obtaining sucrose from sugar cane.

12. What is cholesterol (line 13)? Where would you find cholesterol? What harm is it thought to do to humans?

13. Explain the science behind the concept of raising sunken ships using polystyrene balls (line 4).

★★

NEW SAUSAGE SKIN

130

What are sausage skins made of? Generally sausage skins or casings are made of top quality sheep intestines. These are often hard to get. Pig and beef intestines are then used but not as successfully. They are difficult to stuff with sausage meat and their wall thickness and diameter varies too much.

One company found a way to solve the skin problem. They made casings from collagen, which is a fibrous high-protein substance found in animal hides and tendons. To make the collagen skins, beef tendon is cleaned, frozen and finely sliced, forming a fibrous mash. It is then mixed in a gelatin solution. The next step is to force it through a ring-shaped nozzle to make the casing and then into a coagulating bath of ammonium sulfate solution. At this stage the wall thickness of the casing is about 0.04 cm. This decreases to 0.0025 cm after a series of tanning and drying treatments.

The skin is finally cured for 16 hours at 80^0C. The result is a thin walled sausage casing. A bonus is that this casing will not burst during cooking.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

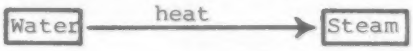
1. What do these words mean as they are used in the passage?
   solve (line 6), coagulating (line 11), solution (line 12) cured (line 15).

2. Why was a substitute sausage skin needed?

3. What was the problem with pig and beef intestines?

4. Construct a flow chart of the manufacturing process of collagen sausage skins. (Remember to put your products in the boxes and the processes on the arrows).

   e.g.



5. How many times thinner is the finished sausage skin compared with the skin before tanning and drying?

RESEARCH QUESTIONS

6. What is collagen (line 7)? Where is it found and how is it obtained?

7. What is the chemical formula for ammonium sulfate?

8. What other substances are used to make sausage skins? (Try asking your local butcher).

9. What do butchers stuff into sausage skins?

10. Sausages must be cooked thoroughly because of the risk of infection by parasites. What are these parasites called and how do they affect humans?

11. What are the advantages of using synthetic skins rather than sheep intestines?

SOURCE: Life Science Library - Energy ★★★

ENTROPY - A HEAT DEATH. 131

When steam comes out of the spout of a kettle, its molecules are going one way - out. Within moments, however, the steam dissipates and its molecules go flying in every direction. As they spread, their heat goes to warm the cooler air. They gradually lose their useful energy - the energy which could have been used, say, to run a steam engine.

Nature has a tendency to equalise temperatures. If it were not for differences in temperature, none of our machines which convert heat to other forms of energy could operate. In the same way that water can turn a wheel only if it runs downhill, so heat can do work only when it flows from a hot place to a cold one. This principle applies not only to machines but also to nature. The constantly changing weather of our planet depends on differences in heat levels around the globe. Wind, for instance, is largely caused by hot air rising and cold air moving in to take its place.

The measure of just how evenly the heat of the universe is distributed is called entropy. This term was invented by the German physicist Clausius in 1865. Increasing entropy - the continuous dilution of heat and order has cosmic implications. For nearly a century, there has been wide-spread speculation that the whole universe might be running a self-destroying race towards maximum entropy. Eventually, according to this theory, there must come a time when the whole cosmos will level out to an absolutely uniform temperature.

When this occurs, no more work will be done. All processes will stop, and so, say some, will time.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in the passage?

   molecule (line 1), dissipates (line 2), convert (line 7), principle (line 10), entropy (line 15), dilution (line 16), cosmic (line 17).

2. Where does the energy of the steam molecules go?

3. What is meant by nature has a tendency to equalise temperature (line 6)? Give an example to illustrate your answer.

4. What, exactly, is the principle referred to in line 10?

5. The passage is headed "Entropy - A Heat Death". What do you think is meant by the phrase "A Heat Death"?

RESEARCH QUESTIONS

6. Name a machine which man uses to convert heat into
   (a) kinetic energy
   (b) electrical energy
   (c) light energy.

7. If the energy of molecules of heated substances goes to warm the cooler air (lines 3 and 4), and this has been occurring for many years, why isn't our atmosphere unbearably hot?

★★

IS EARTH'S OXYGEN RUNNING OUT? 132

Will man, as a result of his needless dumping of wastes and his exploitation of the Earth's resources find himself running short of oxygen and other chemicals necessary for sustaining life?

Every year we are removing more oxygen from the atmopshere by burning more fossil fuels. At the same time we are reducing the amount of oxygen going into the atmosphere by clearing a million acres of the photosynthetic plants which produce oxygen.

A decrease in the amount of oxygen in the atmosphere could also come about as a result of gradual destruction of planktonic diatoms in the oceans by toxic garbage. These planktonic diatoms produce 70% or more of the atmosphere's oxygen by photosynthesis. It is estimated that some half a million substances including materials such as pesticides, radioisotopes, and detergents are now being dumped into the oceans. The Earth's living things might not be able to adapt to many of these products. Only a few of the substances have been tested for their effects on cycles such as the oxygen cycle and the nitrogen cycle.

Man must have green plants to produce the oxygen he needs. For this reason schemes such as the UNESCO plan to develop the Amazon Basin for agriculture have been judged impracticable. Man's influence on the Earth is now so predominant that he must stop and think about the implications of his actions.

Fundamentally, the problem of exploitation of the Earth's resources comes down to the fact that the Earth is nearing its population capacity. We need co-operation between social and natural scientists to try to decide what an optimum size for the human population should be and then work out how we could achieve and maintain that number.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? exploitation (line 2), resources (line 2), planktonic diatoms (line 9), pesticides (line 12), predominant (line 20), fundamentally (line 22), population capacity (line 23).

2. What factors are contributing to the decreasing amount of oxygen in the atmosphere?

3. What solution to the problem is proposed by the article?

4. The article implies that man has been scientifically irresponsible. What form has this irresponsibility taken?

RESEARCH QUESTIONS

5. Draw diagrams of the oxygen cycle and the nitrogen cycle and label them. Indicate where the cycles will be disrupted by the problems referred to in the passage.

6. What is meant by the term biodegradable?
Make a list of substances which man uses regularly which, in your opinion, would be biodegradable.

7. What do the initials UNESCO mean? What is their origin?

8. What was the UNESCO plan for the Amazon Basin? Do you agree that it may had had bad effects on the future of man or was it a good idea?

9. What do social and natural scientists do? Who are they and what would be the role of each in solving this problem?

PERPETUAL MOTION

Sooner or later every child who spends time with electric motors and generators has a brilliant idea. Why not hook the shaft of the motor to the shaft of the generator so that the motor drives the generator, which generates power to drive the motor.

The young inventor does not know it, but this is simply repeating steps taken by brilliant minds over the centuries in the absorbing search for perpetual motion. It is safe to say that no machine of this sort has ever worked. Leonardo da Vinci concluded that most such schemes were bound to fail. He said "O speculators about perpetual motion, how many vain chimeras have you created in the question? Go and take you places with the seekers after gold."

The French Academy of Sciences in 1775 finally closed its doors to any more perpetual motion plans saying; "This sort of research .... has ruined more than one family, and in many cases, mechanics who might have rendered great services, have consumed their fortune,their time and their genius on it."

Neither the academy nor Leonardo knew the basic laws that deny the possibility of perpetual motion. This knowledge was to come only with a much more complete understanding of the nature of one of energy's most elusive forms, heat.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words as used in the passage?

   generators (line 2), power (line 4), perpetual (line 7), chimeras (line 10).

2. What is the design for a perpetual motion machine often thought of by students?

3. What is a perpetual motion machine? What sort of fuel could be used to work one?

RESEARCH QUESTIONS

4. What did Leonardo mean when he said "go and take your places with the seekers after gold." (lines 10 and 11)?

5. What basic laws were unknown by Leonardo and the French Academy? How are these relevant to this situation?

6. Leonardo da Vinci, Sir William Congreve and Archimedes all designed perpetual motion machines. Find out about one of these, give a diagram of the machine saying how it was supposed to work, and why it didn't work.

SOURCE: New Horizon Library. Atoms & Energy. ★★★

RADIOACTIVE DECAY

134a

When atoms of a radioactive element produce alpha particles or beta particles, they change into different atoms.

The speed of the change varies from one radioactive element to another. It is measured by a quantity called the *half-life*. The half-life is the time it takes for half of *any* amount of an element to undergo change or radioactive decay. If the half-life of an element is one hour, for example, half of a sample of the element will change into another element in one hour. But the remaining half will not all change over the next hour. It must be considered as a separate sample, and half of it will change over the next hour that is, a quarter of the original amount, leaving a quarter. Then, over the third hour, a half of this quarter will change, leaving an eighth, and so on. As every half-life period goes by, a sample of a radioactive element decreases by a half, then a quarter, an eighth, a sixteenth, a thirty-second, a sixty-fourth, and so on.

The half-lives of some radioactive isotopes are only a fraction of a second. But others, such as uranium-238 and thorium-232 last for thousands of millions of years. By measuring the amounts of these long-lived isotopes that are left in rocks, geologists can estimate how old the rocks are, and even when the Earth was formed. The half-life of uranium-238 is 4500 million years, which is about the same age as the Earth. This means that there was twice as much uranium-238 in the Earth when it was formed, and since then half of it has changed into other elements.

A radioactive element may change into another radioactive element, which then itself changes into another, and so on. A radioactive series occurs, with a whole sequence of radioactive elements being formed, until finally one changes into an element which is not radioactive. Then the series stops. There are three natural radioactive series. They start with uranium-238, uranium-235 and thorium-232, and all end as non-radioactive isotopes of lead after many millions of years.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   radioactive (line 1), element (line 6), isotope (line 17), series (line 27).
2. What is meant by the term half-life (line 4)? What is the half-life of uranium-238?
3. What evidence is there that half of the earth's uranium has changed into other elements (lines 21/22)?
4. If bismuth-214 has a half life of 20 minutes how much bismuth-214 would remain after 1 hour if there was initially 128 grams?
5. How long would it take bismuth-210 to decay to a sixty-fourth of its original mass? Bismuth-210 has a half life of 5 days.

6. Explain how the half-life concept is used to determine the age of rocks and fossils. What assumptions does this method make?

7. In the terms uranium-238 (line 16) and thorium-232 (line 16), what do the numbers stand for?

8. What changes occur in the nucleus of an atom when it undergoes

   (a) alpha decay?
   (b) beta decay?
   (c) Explain the structure of each particle.

SOURCE: New Horizon Library "Atoms and Energy" ★★★

135a

NUCLEAR ENERGY : BOON OR THREAT?

Supplies of coal and oil are limited and our demand for energy is always increasing. Many nations have to import large amounts of fuel such as oil to keep up industrial production and living standards. Faced with diminishing reserves and uncertainties about the fuel supply from abroad, these countries have looked for other ways of obtaining enough energy. Producing electricity by nuclear fission is the most widely used at the moment. Without power generated by fission, the lives of many people would become less comfortable. An extra benefit is that nuclear power stations do not pollute the air as coal-fired and oil-fired stations do.

Nuclear power helps us in other ways. The production of radioisotopes has advanced industry and medicine, and new uses are being found for them all the time. And there are possibilities that nuclear explosions could have important peaceful uses. Underground explosions could help break up mineral deposits and make them easier to obtain. Canals could be dug and harbours blasted in solid rock more easily with nuclear explosives than with ordinary explosives. The explosions can be made to produce little radioactivity, but more research is needed before they can be used safely.

Safety is the most important question that is raised about nuclear energy. The production and use of nuclear energy always releases radiation, and radiation is very harmful to life. Unless nuclear energy is strictly controlled, it presents a grave threat to us all. One problem is that it is difficult to find out whether there is a safe level of radiation that people can absorb without harm. The longer we live with nuclear energy, the more we find out about the effects of radiation. And it is possible that low levels of radiation may have long-term harmful effects. Some people believe that the tiny increases in radiation that have occurred since man began to use nuclear energy have caused an increase in birth defects. Although safe limits are published for radioactivity, it is possible that no amount of radiation, however small, is harmless.

Radiation may enter our bodies from many causes. A little inevitably leaks from nuclear power stations, however strong their safety measures. There have been small accidents at power stations that resulted in some radioactivity being released.

The waste that nuclear stations produce is highly radioactive. The volume of waste is not large but the radioactivity is intense and extremely dangerous. Nuclear waste is usually stored in tanks with thick walls that absorb the radioactivity. But tanks corrode and may eventually split open, and radioactivity can last for thousands of years. Nuclear authorities are investigating dumping as a way of disposing of nuclear waste. It might be buried in the ground or dumped into the sea. But the movements of ground and sea are too uncertain to make this method of waste disposal completely safe. As nuclear power increases, waste disposal problems will increase.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words and terms mean as they are used in the passage?

   industrial production (line 3), diminishing (line 4), nuclear fission (line 6), radioisotopes (line 10), corrode (line 37), disposing (line 39).

2. Name four advantages of nuclear energy mentioned in the passage.

3. Why is the disposal of nuclear waste material a problem?

4. Why are supplies of coal and oil limited (line 1)?

5. Briefly describe the various types of radioactivity and their effects on living cells.

6.(a) Explain in more detail what nuclear fission is. Give an example to illustrate your answer.
(b) What is the difference between nuclear fission and nuclear fusion?
(c) Which would be a better source of nuclear power? Why?
(d) Why don't we use nuclear fusion as a source of power at present?

7. How safe are the world's nuclear reactors? Make a list of nuclear "accidents" which have occurred in the last 10 years. Have any lives been lost? What damage was done?

8. What do nuclear authorities mean by dumping (line 39)? What precautions are taken in dumping nuclear wastes?

SOURCE: "Sun-Herald" August 27th 1978. ★★

136

NEW BID TO STEM NUCLEAR LEAK

ROCK, KANSAS, Saturday (AAP). - Airforce workers dumped thousands of litres of ammonium hydroxide into an underground Titan II missile silo today, hoping to neutralise leaked rocket fuel that killed one serviceman and seriously injured two others.

Clouds of billowing smoke and steam rose above the underground missile site near Wichita, a result of the heat created by the chemical reaction of the ammonium hydroxide being poured through the open silo doors with the poisonous propellant dinitrogen tetroxide.

Air Force officials said steam clouds created by the neutralisation were harmless and the substance formed by the reaction was ammonium nitrate, a basic fertiliser.

"There's no danger at all to this neutralisation we're doing. It's perfectly safe," said a Strategic Air Command spokesman.

On Thursday, a caustic corrosive orange cloud of dinitrogen tetroxide forced hundreds of nearby residents to flee for their lives.

Those evacuated were kept from returning today as the dumping began and no air force officials were willing to predict when they could come back.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article?

   silo (line 2), neutralise (line 3), billowing (line 5), propellant (line 8), basic (line 11), caustic (line 14) corrosive (line 14), evacuated (line 16).

2. Name a product of the neutralisation reaction.

3. Was heat absorbed or liberated during this reaction? Give a piece of evidence to support your answer.

4. A textbook gives the following changes to dinitrogen tetroxide with increasing temperature:

   -10^0C colourless or very pale yellow solid.
   10^0C yellow liquid.
   22^0C boils with an orange colour.
   30^0C a reddish brown gas.
   40^0C nearly black gas.

   From this information, at what temperature was the dinitrogen tetroxide which forced hundreds of residents to flee?

5. The heading of the article states that there was "a nuclear leak" at the missile silo. Comment on the accuracy of this heading

RESEARCH QUESTIONS

6. What are the chemical formulae for the substances mentioned in this reaction: Ammonium hydroxide, dinitrogen tetroxide, ammonium nitrate?

7. Dinitrogen tetroxide was used as an oxidiser in the propulsion system of the first lunar landing craft.
   (i) What is an oxidiser?
   (ii) Find out more about dinitrogen tetroxide.

SOURCE: "The Sun" Friday May 4th, 1979 p. 13 ★★

137

MYSTERY 'LEAKS' IN 15 PLANTS

Scientists are baffled by a corrosion problem, causing pipes to crack and leak small amounts of radioactive water, in at least 15 nuclear power plants in the Unites States.

Meanwhile, in Britain, Dungeness Nuclear Power Station, has been shut down because of faults in the cooling system caused by cracks in one of the reactors.

The problem in the United States has caused extensive pipe damage in the steam generators of five nuclear power plants and "minor" damage at 20 other plants.

Darrell Eisenhut, Deputy Director of the Nuclear Regulatory Commission said a chemical reaction involving acids- chlorine and salt causes a corrosive build-up between the pipes and their metal fittings, creating pressure.

He said the only solution now appears to be replacing the pipes.

Scientists have been unable to develop a chemical to dissolve the corrosion build-up, he added.

At Dungeness, minute cracks in one of the "A" reactors has led to an 8-month shutdown, costing $555,000 a week.

The plant produces Britain's cheapest electricity.

A spokesman said of the cracks: "You might almost call them scratches".

He stressed there was "absolutely no question of a safety or radiation hazard at all."

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? baffled (line 1), radioactive (line 2), reactors (line 6) extensive (line 7), generators (line 8), hazard (line 21)

2. There is a spelling mistake in the first paragraph. When you have found it write the word correctly. What does it mean?

3. What is causing the pipes to crack and leak?

4. Why should scientists be worried about this leak?

5. What have scientists tried to do to overcome this problem?

6. Calculate the approximate cost of the eight-month shutdown of the Dungeness "A" reactor.

7. Who stressed to the reporters that there was "absolutely no question of a safety or radiation hazard at all"? Why do you think he stressed this point to them?

RESEARCH QUESTIONS

8. Draw a diagram of a nuclear reactor. Label your diagram and explain how the reactor works.

SOURCE: "Sydney Morning Herald" 18th June, 1974 p.10. ★★★

138a

PLAUSIBLE THEORY ON LUNG CANCER

A recent article in the scientific journal "Nature" written by Dr. Edward Martell, of the US National Centre for Atmospheric Research in Boulder, Colorado, offers a plausible theory to explain how smoking may actually cause lung cancer.

There is no doubt whatsoever that smokers have a greatly increased chance of contracting lung cancer than non-smokers. Yet such a correlation does not necessarily mean that smoking is the direct cause of lung cancer; it could be that some other factor promotes both the inclination to smoke and an increased probability of contracting the disease.

It is because of such arguments that medical research has been directed towards establishing whether smoking is a direct cause of lung cancer.

One theory is that the tars carried in tobacco smoke, some of which are deposited on the walls of the lungs, are a prime cause of cancer. It has been established, for example, by experiments on mice, that such tars have carcinogenic effects.

In his article in "Nature", Dr. Martell refers to scientific evidence that tobacco, cigarette smoke and smokers' lungs contain a radioactive isotope of lead-210. This isotope decays radioactively to polonium-210, which is an emitter of extremely strong radiation in the form of so-called alpha particles - which are in fact the nuclei of helium. It is well known that radioactive substances which emit alpha particles are very prone to produce cancerous conditions.

Of all the theories which attempt to connect smoking as a direct cause of lung cancer none has as yet explained the long delay between smoking and onset of cancer. Martell's theory does this.

The lead-210 converts very slowly to polonium-210 and has what is known as a half-life of 21 years. This means that of a given amount of lead-210, one half will have converted in 21 years.

Once the polonium-210 is formed, however, it emits its alpha particles relatively rapidly with a half-life of only 138 days, ending up in the form of stable lead-206. This alpha particle radiation, which may induce the cancer, can occur long after the radioactive particle was deposited.

As early as 1965 the well-known New Zealand scientist Sir Ernest Marsden, writing in the "New Zealand Medical Journal" put forward a theory somewhat similar to Dr. Martell's.

Marsden's article was entitled, "Some aspects of the relationship of radioactivity to lung cancer" and suggested that polonium-210 was "present in many tobaccos in quantities sufficient to suggest that these may well be responsible for most of the carcinogenic effects observed".

The Marsden article received a considerable amount of publicity, but eventually his theory was discounted on several grounds - one being the relatively short half-life of polonium-210. This would mean that, even if the substance were at one stage present in tobacco plants it would have decayed before the cigarette was smoked.

The new theory, however, completely overcomes this difficulty by attributing the effect to the long-lived lead-210, of which polonium-210 is an eventual by-product. Moreover, lead is well known to accumulate in the body and a smoker could have a significant accumulation in his lungs.

Precisely how the lead-210 finds its way into or attaches itself onto the tobacco leaves, and thus into the smoker's lungs is a subject yet to be studied.

At the same time, Martell's paper highlights an additional possible danger of ordinary lead pollution which exists for many reasons, of which
55 one of the major ones results from lead additives in petrol.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   plausible (line 3), correlation (line 6), carcinogenic (line 16), isotope (line 19), helium (line 21)

2. Sir Ernest Marsden proposed in 1965 that the radioactive Polonium-210 produced from lead in tobacco causes lung cancer. Why was his theory discounted?

3. What alternative theory to Marsden's is proposed in the article?
   Why is it a more acceptable theory?

4. What other important source of lead-apart from tobacco smoke - is mentioned in the article?

RESEARCH QUESTIONS

5. The article points out that smoking is known to be correlated with lung cancer, but it isn't known whether smoking causes lung cancer. Give another example of this.

6. "... radioactive substances which emit alpha particles are very prone to produce cancerous conditions".(lines 21/2/3). Find out how they do this.

7. Write nuclear equations for the radioactive decay of:

   (i) Lead-210 to Polonium-210
   (ii) Polonium-210 to Lead-206.

★★★

SOURCE: Adopted from New Horizon Library. Atoms & Energy.

RADIATION AND ITS DANGERS

139a

When alpha particles strike atoms, they change the nuclei of the atoms turning them into atoms of other elements. If beta particles (electrons) strike atoms, they will give the atoms an electric charge. Alpha particles also charge atoms, because they are electrically charged themselves.

If alpha and beta rays strike the human body, the particles in them change the atoms there. This can be very dangerous, because our bodies are made up of many chemical compounds working together in a delicate balance. If the compounds in our bodies suddenly start changing, illness, perhaps even death, may result.

Rays and particles like these are often called *radiation*. There is a third kind of radiation produced when nuclei change - gamma rays. (Gamma is the third letter of the Greek alphabet and written γ.) Gamma rays are not streams of tiny particles like alpha and beta rays. They are a form of very strong X-rays and, like X-rays, gamma rays can easily penetrate matter.

Alpha particles are not a great hazard to life. They are not very penetrating and are in fact stopped by the outer layer of the skin. Beta rays are more penetrating and can get inside the skin. But gamma rays are so penetrating that they can pass right through the body, just as X-rays can. They cause harm to the atoms in the body. X-rays also cause harm, and this is why you should avoid having too may X-ray examinations.

Protection from Radiation

Nuclear physicists and people who work at nuclear power stations all face danger from radiation. The materials they use are often radioactive and produce radiation. In fact, we all receive a small amount of radiation every day. This radiation comes from the natural radioactivity of some minerals in the ground, and also from cosmic rays and other rays striking the Earth from outer space. But this natural radiation, which is known as background radiation, is very slight, and is harmless.

Man-made radioactivity is far stronger than natural radioactivity. People who have to handle radioactive materials do so with special tools and shield themselves behind thick screens that absorb the radiation. Workers who have to go into radioactive areas wear special plastic suits with their own air supply. The suits are washed down to remove radioactive particles before they are taken off.

All the people in nuclear power stations and nuclear laboratories have instruments to detect radiation. They each wear a film badge - a small piece of film inside a plastic holder. The film is developed at regular intervals and replaced with a new piece. If the wearer of the badge has received any radiation, the film appears black when developed. Other instruments that immediately detect radiation include the Geiger counter. This is an electronic instrument and shows how strong the radiation is. Among its uses, the Geiger counter is employed in prospecting for radioactive minerals such as uranium.

The designers of nuclear buildings try to make sure that no radioactive dust or other dangerous materials can leak into the air. Radioactive places, and containers of radioactive materials, are all marked with the international radioactivity symbol to warn people to take care.

DO NOT WRITE ANY ANSERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? penetrate (line 16), atoms (line 21), radioactive (line 25), minerals (line 28), cosmic (line 28).
2. Draw up a table which shows: Two types of radioactivity, Nature of the radioactivity, Penetrating power, Protections against.
3. Why is radioactivity dangerous to life? What sort of things can occur to a body exposed to lots of radiation?
4. What is background radiation (line 30)?
5. How are people who work in nuclear establishments protected from radioactivity?

RESEARCH QUESTIONS

6. The article states that background radiation is ... harmless (line 30).
Is this so? Explain your answer.

7. Radiation can be used to man's advantage. List two situations where man does use radioactivity, but give only one medical use.

8. What does the international radioactivity symbol look like?
Why is it used?
Where is it used?

SOURCE: Sun-Herald September 10th, 1978. ★★

140

SCARE ON DEADLY PELLETS

PERTH - Cyanide pellets, giving off a highly toxic and flammable gas, created a major emergency yesterday when they were scattered beside the Great Eastern Highway.

The emergency occurred at Wooroloo, 56 km from Perth.

Twelve big drums of sodium cyanide burst when they fell from a truck about 3a.m.

The gas, given off when the chemical is wet by rain, is the same used in gas chambers for executions.

Firemen covered the pellets with protective sheets to shelter them from rain.

They were dressed in special protective clothing in case the gas blew up.

The highway was blocked off for more than seven hours.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as used in the article? pellets (line 1), toxic (line 1), flammable (line 1), protective (line 9).

2. Does sodium cyanide react with water? How do you know?

3. Why did the firemen cover the pellets with protective sheets?

4. What *two* conditions at the time of the accident would make it difficult for the firemen to clean up the chemical?

5. i. What type of article is this? Persuasive? Informative? Critical? Derogatory?
   ii. Is this article objective or subjective?

RESEARCH QUESTIONS

6. Find out the name of the gas used in gas chambers.

7. Write a balanced equation for the reaction between the sodium cyanide and the rain (water).

BIOLOGICAL CONTROL

The most spectacular example of biological control was achieved in California. In the 1880s, the citrus groves in California became infested with fluted scale. The infestation was so heavy that the survival of the industry was threatened.

It was noticed that the scale insect was also present in Australia. Here, however, it did not affect the citrus trees. It was thought that perhaps the fluted scale had been introduced into California without its natural enemies. It was also thought that if these natural enemies could be brought in, a balance might be restored.

An entomologist was sent to Australia from California. He soon discovered the parasitic fly *Cryptochaetum*. This insect specialised in laying its eggs in scale insects. He also noticed the small ladybird beetle *Rodolia cardinalis*. This preys exclusively on the larvae and adults of the scale insects.

A few of each were sent to California and released on an infested tree enclosed in a tent. Within two weeks it was free of scale insects. The beetles were then released in a small orchard where the results were the same. They spread and were carried from one grove to the next. Within a year it was clear that the citrus industry had been saved. The fluted scale had virtually disappeared.

The same triumph has been repeated all over the world wherever the scale insect was imported without its natural enemies.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words or phrases mean as they are used in the passage?

   citrus (line 2), infestation (line 3), natural enemies (line 8), parasitic (line 11), exclusively (line 13).

2. This article gives us a good example of a practical application of the scientific method. Use the information in the passage to identify these aspects of the scientific method:

   (i) an initial observation
   (ii) a problem identified
   (iii) research into the problem
   (iv) formation of hypotheses
   (v) controlled experiment
   (vi) experimental results
   (vii) further experimentation
   (viii) experimental results
   (ix) conclusion.

RESEARCH QUESTIONS

3. What are the characteristics of a biological control?

4. Are there any dangers to avoid when using a biological control?

5. What are some examples of biological control used in Australia?

6. Are all the agents of biological control parasites? Is this an essential characteristic of biological control? Explain.

SOURCE: "Sun-Herald, Nov. 12, 1978. ★★

142a

VEGEMITE IN WAR ON GARDEN PESTS

Vegemite - that great staple of the Australian diet - might soon become the new wonder weapon of farmers and home gardeners in their battle against crop-devouring pests.

It seems the savoury spread we lavish on toast and sandwiches is equally as tasty to some tiny insect predators.

Melbourne zoologist, Dr. Tim New, says diluted with water and sprayed on fields of crops, Vegemite attracts green lacewings - helpful little insects scientifically known as Neuroptera.

In the adult stage they thrive on solutions of yeast hydrolysates - and that includes Vegemite.

But their hungry young have an insatiable appetite for garden pests such as aphids, caterpillars, and other scale and soft-bodied insects.

"The idea is to encourage these natural predators into a crop so they are ready and waiting when the pests arrive", said Dr. New, a senior lecturer in zoology at La Trobe University.

"Most pest infestations occur at predictable times of the year and its only when they reach plague proportions that the natural predators appear.

"By this time, the pests have already done the damage.

"If we supply the predators with a nourishing food source, such as Vegemite, early in the season, they will stay and breed and be on hand to deal with any pest infestation."

Dr. New says using hydrolysed yeast sprays would help lower the levels of environmental pollution caused by the present reliance of broad-spectrum chemical herbicides and pesticides.

Although the Vegemite idea seems a little far-fetched, Dr. New says the method has been tried and proven in the United States.

However, the Americans use a different commercial product similar in its constitution to Vegemite.

Dr. New said it was becoming increasingly urgent for gardeners to realise that using chemical sprays was like deploying land mines against stray cats.

"The chemicals not only kill pests but also the natural predators," he said.

"They can be harmful to bees and will probably take years off your own life.

"So little research has been done on the long term effects of these chemicals and there's a strong possibility that some of them may cause genetic defects."

He believes that within a few years most insect pests will become immune to chemical sprays and that science will have to find other viable alternatives.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do the following words mean as they are used in the passage?

   staple (line 1), devouring (line 3), lavish (line 4), predators (line 5), insatiable (line 11), infestations (line 16), constitution (line 28), deploying (line 30), viable (line 39).

2. List the advantages of spraying a garden with diluted Vegemite instead of insecticide.

3. What does the term broad-spectrum (line 23) mean?

4. Which of the following food chains can be constructed from the information in the article?

   A. Vegemite → aphids → green lacewings.
   B. Vegemite → green lacewings → aphids.
   C. Crops → aphids → scale insects.
   D. Crops → caterpillars → green lacewings.

5. Find the *analogy* used in this article. Is this analogy effective? Explain.

6. In the article, Dr. New lists five disadvantages of the use of chemical insecticides. What are they?

RESEARCH QUESTIONS

7. (i) What are yeast hydrolysates (line 9)?
   (ii) Name two other foods which contain yeast hydrolysates.
   (iii) Can these foods be used instead of Vegemite on the garden?

8. Draw a diagram of the green lacewing.

9. Why do you think the insect is called the lacewing?

10. What are some of the characteristics of the adult green lacewing?

11. The larval stage of the lacewing has an interesting food collecting and eating behaviour. What is it?

12. In the last paragraph, Dr. New stated that alternatives to chemicals will need to be found. What are some of the non-chemical ways scientists are using to control insect pests at present?

★★★

STERILE MALE TECHNIQUE WORKS WITH RATS

143a

The war on rats gains a new weapon with a chemical which with one dose leaves male rats permanently sterile. Except for this key point, treated rats are as healthy, energetic, and as aggressive as before and maintain their previous position in the rat population.

It has been recognised for some time that sterile males retained in a population are probably more effective in controlling its number than if the same number of fertile males were removed. Sterile animals continue to compete for territory, food, social order and most importantly, for sexual partners. In the case of rats the number of litters is reduced because female rats after mating with sterile males develop a false pregnancy which prevents further mating with other males. This type of population control has been effectively carried out with various fly species over local areas by releasing multitudes of artificially bred, but sterilised, insects.

The chemical developed against the rat is a member of the chlorohydrin family and has been investigated by the Upjohn Corporation of Kalamazoo. The drug (3-chloro- 1, 2- propanediol) causes lesions in the male rat's reproductive tract which results in permanent blockage preventing sperm release. Although the testing of the chemical is still proceeding it has been proved to be relatively non-toxic to wildlife, domestic animals and man.

Being effective after just one dose is perhaps the greatest asset of this chemical. Present effective rat poisons are of the cumulative type - they require repeated ingestions. The anti-coagulants warfarin and fumarin are examples, and often rats become bait-shy before enough is consumed to cause death.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of these words as they are used in the passage?

   sterile (line 2), territory (line 8), litters (line 9), multitudes (line 13), lesions (line 16), cumulative (line 21), ingestions (line 22).

2. Explain what is meany by the following terms:

   false pregnancy (line 10), reproductive tract (lines 16/17) bait-shy (line 23)

3. The word *family* (line 15) is used in this article with a chemical meaning. Explain what is meany by a 'family' of chemical substances.

4. What is meant by the term *anti-coagulant* (line 22)? How do anti-coagulants work?

5. What advantage has the new chemical over previous chemicals used to control rat populations?

6. Why is the fact that the chemical is effective after one dose such an asset?

7. Why is it important that treated rats remain healthy, energetic, and as aggressive as before (line 3)?

RESEARCH QUESTIONS

8. This method of controlling pests is often called *biological control*. Why do you think this name is used?

9. Describe one example of biological control of insect pests, explaining how it works and why it is used.

10. For Chemistry Students. Draw the structural formula of the drug 3- chloro - 1, 2- propanediol (line 16) mentioned in this article.

SOURCE: The Australian Museum Leaflet No. 18, February 1968. ★★

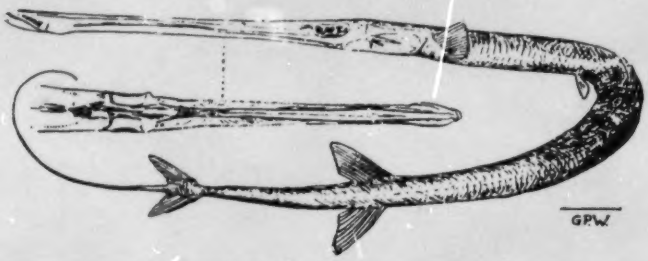
THE FLUTEMOUTH

144a

THE flute-like snout with a small mouth at the end of its tube, the long cylindrical body and the weak fins are characteristic of the Flutemouth. It is unique among fishes because at the fork of the tail a long ray extends like a filament.

The Flutemouth is not uncommon along our rocky coastlines. It is sometimes cast ashore after heavy weather. Occasionally it takes a hook with a fish bait. It was called "The Tobacco Pipe Fish" by the men of the First Fleet, and was figured as such in John White's *Journal of a Voyage to New South Wales*, published in 1790. The Flutemouth grows to about 1.8 metres in length, 3.5 kilograms in weight, and may be brown or pink in colour. It has the ability to change its tones to harmonize with its surroundings. It is found around the northern coasts of Australia, and at Lord Howe Island, and elsewhere in the tropics, ranging from shallow water down to about 90 metres. At these depths it is preyed upon by Saw-sharks and large fishes. The Flutemouth eats small fishes and other marine animals, and is itself good eating. It is distantly related to the Sea-horses and Pipefishes.

There are two Australian species, the common brown *Fistularia immaculata* Cuvier, 1816, usually found on New South Wales beaches in winter, and the rare Red Flutemouth, *F. villosa* Klunzinger, 1871, more of a tropical species, with rougher skin.



DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What is the meaning of the following words, as used in the article?

   snout (line 1), characteristic (line 2), filament (line 4), harmonise (line 12), preyed (line 15).

2. Why is this fish called a Flutemouth?

3. What makes the Flutemouth one of a kind among fishes?

4. What does the author mean by the words distantly related (line 18)?

5. What do you think *F.* stands for in *F. villosa* (line 21)?

6. The Flutemouth shown in the diagram was caught off Botany Bay, New South Wales. Which of the two species mentioned in the article is it more likely to be?

7. (a) What is the length of the Flutemouth in the diagram?

   (b) Is it a fully grown specimen? Explain.

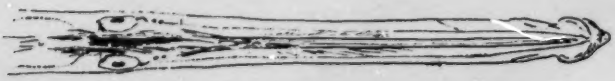
8. Estimate the approximate mass of the Flutemouth in the diagram.

RESEARCH QUESTIONS

9. Explain what is meant by the term: *Fistularia immaculata* Cuvier 1816 (lines 19 and 20).

10. There is an inaccuracy in line 11. What is it?

11. The following is a diagram of the snout of a specimen of *Fistularia villosa* drawn to the same scale as the previous diagram.



Give an estimate for the length of this specimen.

SOURCE: How and Why Wonder Book of Light and Colour.

SHADOWS

145

Look at someone walking down a road in the sunlight and you will see a shadow. Now suppose you watched two people carrying a 2 metre pane of glass between them. You would see the shadow of each person 2 metres apart but there would be no shadow of the pane of glass.

Shadows are easily explained if we consider that light travels in a straight line. We also know that light passes through some objects and not through others.

When light strikes an object and passes through it unchanged, we say that the object is transparent. Most glass is transparent, and it is for this reason that you would not see the shadow of the pane which the people were carrying. Another transparent material is air. Another is clear water.

On the other hand some materials do not let light pass through them at all. They stop light just as you would catch a ball that was being thrown to someone standing behind you. Such materials are called opaque. Our bodies, like steel, wood, rocks, concrete and cardboard, are opaque, and therefore do not permit light to pass through them. An opaque object casts a shadow.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage? pane (line 2), transparent (line 9), materials (line 14), opaque (line 14), permit (line 16), casts (line 16)

2. Two properties of light cause shadows. What are they?

3. The article mentions several transparent objects or materials and several opaque materials. Make a table with two columns headed "Transparent Materials" and "Opaque Materials". In the table list the materials mentioned in the passage in the correct column and add more until you have 10 of each.

4. Why do you cast a shadow, when a pane of glass does not?

RESEARCH QUESTIONS

5. (a) Give 5 different uses for transparent materials.
   (b) Give 5 situations where the use of transparent materials would not be satisfactory.

6. What is a *translucent* material?
   Give an example of such a material.
   Why are bathroom windows generally made from translucent glass?

SOURCE: Light and Colour, F. Healey, Hart Davies 1962. ★

REFLECTION 146

When you comb your hair in front of a mirror you can see yourself because the mirror throws back the light. This is called *reflection*. We say the mirror reflects light. If you stand to the side of a mirror and look into it you can't see yourself. What you do see is anything on the other side of the mirror reflected in it.

This is rather like kicking a ball against a wall. If you kick the ball straight at the wall it will come back to you, but if you kick it sideways it will hit the wall then bounce away from you. Light behaves just like a ball.

Almost everything reflects light. If the things around us did not reflect light we could not see them. Without reflection the world would always be dark. When you look at a house or flowers or trees in a garden, or a plane in the sky, you can see these things because they reflect the sunlight. Some things reflect little light, some reflect a lot. A mirror reflects nearly all the light.

Dust in the air reflects light. There is dust in the air everywhere, even in a room which has just been cleaned and dusted. You can see it when a bright shaft of light enters a darkened room. Every grain of dust reflects the sunlight.

On a clear night the moon looks very bright, but we know it has no light of its own. It reflects the light of the sun. The planets also reflect the sun's light. When the earth moves between the sun and the moon, the earth stops the sunlight from reaching the moon. This is called an eclipse.

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1. What do these words mean as they are used in the passage? reflection (line 2), grain (line 18), planets (line 21), eclipse (line 24).

2. How does light behave "like ... a ball" (line 6)?

3. The passage states that without reflection the world would always be dark (lines 11/12). How could this be - the sun would still be shining on it!

4. Draw a diagram to show what the passage means by an eclipse (line 24).

5. Draw a diagram which shows you, the sun, a house and a plane. Draw lines to represents rays of light and show how you see the objects.

6. The sun sets in the west. The moon rises in the east shortly afterwards. How can the moon possibly be seen? Draw a diagram showing the sun, moon and earth and lines to represent rays of light to show why it can be seen.

RESEARCH QUESTIONS

7. What is a periscope? How does it work? Draw a diagram to show how it works. You may show either a prism or mirror periscope.

RADIOACTIVE JEWELLERY

Doctors have reported several cases of severe skin diseases recently. They have linked these to jewellery made from a particular shipment of gold. This gold contains impurities of radioactive radium.

These impurities come from gold which has been used by doctors. The gold is treated to make it radioactive and then used to treat tumours. Small pellets of the radioactive gold are implanted into the tumours. In some cases, the radiation stops cancer cells from reproducing, or even kills them.

After treatment, the gold is removed from the tumour and treated to remove the radioactive impurities. In this way it can be used again and again.

The gold used in the jewellery appears to be reclaimed metal which was not refined properly. Rings which were examined were found to be radioactive. The emitted between 2 and 290 millirads of radiation per hour. The skin disorders caused by the radiation range from simple rashes, to severe dermatitis, to tumours.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the article?

   linked (line 2), tumour (line 5), implanted (line 6), reclaimed (line 12), dermatitis (line 16).

2. How did the gold become radioactive?

3. Why was the gold made radioactive?

4. How did the radioactive gold get into the jewellery?

5. The article mentions radium (line 3) as the radioactive substance in the gold. What is radium? Where does it come from?

RESEARCH QUESTIONS

6. Make a list of 5 other radioactive substances. Are they naturally occurring or man-made? How are they obtained? What are they used for?

7. Who first suggested the treatment of tumours using radioactive substances? What radioactive substance was first used in this treatment? What substances are used today?

8. Radioactivity can *cause* cancers, but as the article shows, radioactivity is also used in *treating* them. How is this possible?
   How do doctors arrange that radioactivity is used to kill cancer cells without harming healthy ones?

SOURCE: Life Science Library - "Energy" ★★

148

HEAT AND TEMPERATURE

Joseph Black, a Scottish chemist was the first man to discover that heat and temperature are not the same thing.

Black placed an iron disc on one burner of a stove and a pan of water of equal mass on another. He heated each for the same amount of time. The iron, after 10 minutes became too hot to touch, while the water was only lukewarm. Equal heat resulted in unequal temperatures. Black concluded that heat is an amount of something, while temperature is the degree of hotness.

Black tested his theory on a number of substances. He found that each one required a different amount of heat to raise its temperature one degree. He called this property of substances "the capacity of heat". Later, scientists arbitrarily assigned the figure "one" as a measure of the heat capacity of water. The ability of other materials to soak up heat, compared to water, is called "specific heat".

Iron, for example, has a specific heat of 0.107. This means it takes only about one tenth as much heat to raise the temperature of iron one degree as it would take to raise of the same mass of water one degree. Strangely enough only two substances have a specific heat greater than that of water, ether (1.041) and ammonia (1.125). This means that water, compared with almost every other substance, is slow to absorb heat and slow to lose it.

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1. What do these words mean as they are used in the passage?
   chemist (line 1), theory (line 9), property (line 11) arbitrarily (line 12), ability (line 13), mass (line 17)
2. What observation did Black make from this experiment?
3. What conclusion did Black make from these observations?
4. Explain the meaning of the sentence Equal heat resulted in unequal temperatures. (line 6).
5. What is "the capacity for heat" (line 11) of a substance?
6. What is the "specific heat" of a substance (line 14)?
7. Place these substances in decreasing order of specific heat: water, iron, ether, copper, ammonia.

RESEARCH QUESTIONS

8. Explain the purpose, in an experiment like this, of the equal mass (line 4), equal heat (line 6) and same mass (line 17).
9. The fact that water has a relatively high specific heat has far-reaching consequences to life on earth. Discuss 2 examples of this.
10. Why did scientists arbitrarily assign the figure "one" (line 12) to the heat capacity of water? Is this a normal practice for scientists?

★★★

FORTY MEN SPEND TWELVE DAYS UNDER THE SEA

149a

The third stage of the U.S. Navy's Man-in-the-Sea program involved putting five diving tanks of eight men each in an under-water habitat known as Sealab III. Sealab III stayed at a depth of 130 metres for 12 days during which time the divers made excursions into the sea.

Sealab III consists of a cylindrical living compartment 3.6 metres in diameter and 17.3 metres long. Two additional rooms 2.4 metres by 3.6 metres are attached to the bottom or hull of the habitat. The forward is an observation and storage compartment with an exit hatch. The after room is a diving station complete with lockers, gear and an open hatch for access to the sea.

The atmopshere in the living compartment is designed for a pressure of 14 Kg per square cm absolute (corresponding to 130m of water) and will contain approximately 92% helium, 6% nitrogen and 2% oxygen. Replenishment gas is piped from the support ship or from external bottles stowed in the habitat. Charcoal is used to remove odours. Heat is supplied by convection heaters and electrical dehumidifiers control the humidity. The temperature is maintained at about 35°C. This would be excessive on the surface but is required in the habitat because of the greater loss of body heat in a helium atmosphere.

Sealab III was supported by a surface ship moored vertically above. The ship had two decompression chambers designed to support four divers. A four-day decompression period was needed to return saturated divers from the pressure at a depth of 130 metres to normal atmospheric conditions. To transport divers from the ship to the bottom of the habitat a pressurised lift was used. This lift mated with the deck compression chambers.

DO NOTE WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
habitat (line 2), replenishment (line 13) saturated (line 21), mated (line 24).

RESEARCH QUESTIONS

2. Draw a longitudinal section (from front to back) of Sealab III labelling as many construction details as possible.

3. What is a convection heater? (line 15) Draw a diagram to show how a convection heater works.

4. What is humidity? (line 16) What is a dehumidifier (line 16)? Explain how a dehumidifier might work.

5. What is a decompression chamber? (Line 20). Explain why a decompression chamber is necessary and how it works.

6. Why is the atmosphere in Sealab III as it is? (line 13). In particular - why so little oxygen?
- why helium?
- why so much helium?

7. Why is the pressure in the living compartment maintained at 14 Kg per square cm? (line 11).

8. What is the correct unit of pressure? Convert 14Kg per square cm (line 11) to acceptable units.

9. Explain, possibly with the aid of a diagram, the structure and use, of an open hatch (line 9). If the hatch is open why doesn't the water rush in?

10. Charcoal is used to remove odours (line 15). Explain why this works. See if you can find 5 other situations which use charcoal (or perhaps some other chemicals) to remove (not disguise) odours.

WORLD BUILDING RECORD?

A 25 metre seven-storey office block was erected in the centre of the German city of Hamburg in 1969, in what may be a record time. In less than three days 346 prefabricated units with a total mass of 25 000 tonnes were assembled to create some 1400 square metres of office space.

This lightning operation was preceded by over a year's preparation of all the necessary component parts of the building. The operation itself began on a Thursday night when a 30 metre crane was erected. The actual office construction began at sunrise on the Friday. Two thirty-man teams, working in shifts, began assembling the prefabricated concrete units. These units were delivered to the site by a shuttle service of trucks in the strict order required and in accordance with a carefully worked out time schedule. Some of the units weighed as much as eight tonnes. They included massive sections of walls, floors, ceilings, pre-cast flights of stairs, lift shafts, and shop fronts complete with neon signs indicating the future tenant. There were even washrooms units complete with toilet, wash basin, mirrors and toilet paper.

The concrete units were fitted together like pieces of a child's construction set. Joints were then welded and cemented over. Work continued at night under floodlights. As soon as each floor was constructed the interior decoration team took over. Therefore, by the time the seventh storey was completed, the lower floors were almost habitable; the walls were painted, lights worked and water came out of taps.

The erection of the building was completed in exactly 65 hours 41 minutes and 23 seconds. The crane was removed again overnight and the traffic flowed again. It has been estimated that it could have taken 5-6 months to build a similar block by conventional methods. It is now possible, therefore, to fill vacant sites in the heart of a busy city quickly and cheaply with the disruptions to traffic and the noise concentrated into a very short time span. In this case it took not much more than one weekend.

DO NOT WRITE ANY ANSWERS ON THIS SHEET. ALL ANSWERS ARE TO BE WRITTEN ON YOUR OWN PAPER OR IN YOUR BOOK.

1. What do these words mean as they are used in the passage?
   prefabricated (line 3), shuttle (line 10), massive (line 12), conventional (line 26),
2. What organisation had to be done in order for this building operation to run smoothly?
3. What was the major time saving factor in the construction of the building?
4. Can you think of any advantages of constructing buildings by this process? Can you list any disadvantages?
5. Approximately how many prefabricated units must have been assembled per hour? What would be the average time per unit?
6. What was the *average* mass of each prefabricated unit? What was the mass of the heaviest unit?
7. If it took over a year's preparation (line 5) and could have been built in 5-6 months by conventional methods (line 26), was time really saved? Explain.

D. West, Government Printer, New South Wales – 1981